CMHC
Canada Mortgage and Housing Corporation

SCHL
Société canadienne d'hypothèques et de logement

Energy Upgrading of Buildings with Central Utilities Funded Under NHA Programs

Research Report

November 1983

Canada

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part V of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

ENERGY UPGRADING
OF
BUILDINGS WITH CENTRAL UTILITIES
FUNDED UNDER NHA PROGRAMS

Prepared for
the Research Division
Policy Development and Research Sector
Canada Mortgage and Housing Corporation

by

Engineering Interface Ltd.
Consulting Engineers
Toronto

Principal Consultant: I. Jarvis, P.Eng.
CMHC Project Manager: Philip Deacon

© Canada Mortgage and Housing Corporation
Cat. No. NH20-1/7-1983E
ISBN 0-662-12893-1

ABSTRACT

An assessment was made of the potential dollar savings that could be made through application of low cost techniques on buildings with centrally operated utilities and a strategy for achieving these savings was recommended. The method of assessment included:

- estimation of the building inventory and a follow-up questionnaire which classified the public housing stock by energy system characteristics and by size;
- detailed studies of buildings selected as representative of the major classifications;
- identification of energy management methods based on site inspections;
- computerized analysis of historical energy records and identification of savings potential;
- analysis and projection of assembled data into estimates of potential savings, and the expenditures needed to achieve them.

1 650 building projects (made up of 145 000 dwellings) were identified as being within the scope of this study (i.e. 20 or more dwelling units per project, centrally operated utilities and funded under NHA). Potential savings were estimated at $10.2 million, or about 13% of current energy costs. The recommended strategy consisted of energy management training for building operators and a continuous monitoring of consumption with feedback to the operator. The cost of implementing this was estimated at $35 million over 5 years.

This study was conducted by Engineering Interface Limited for Canada Mortgage and Housing Corporation. The analysis, interpretations, and recommendations are those of the consultants and do not necessarily reflect the views of Canada Mortgage and Housing Corporation or those divisions of the Corporation that assisted in the study and its publication.

TABLE OF CONTENTS

		Page
Executive Summary		XI
1.	Introduction	1
2.	State of the Art Review	5
3.	Building Stock Estimate	19
4.	Questionnaire Survey	22
5.	Energy Management Methods	32
6.	Energy Analysis	44
7.	Estimation of Potential Savings	54
8.	Conclusions	61
9.	Recommendations	69

APPENDICES

A Information Sources
State of the Art Review:
B Building Stock Estimate: Breakdowns
C Questionnaire Survey: Sample Questionnaire
Database Summary
D Energy Management Methods: Site Survey Summaries
E Energy Analysis: Building Energy Audit Summaries
Worked Example of Energy Audit
Worked Example of Energy Target Setting
Procedure using Ontario Ministry of
Municipal Affairs and Housing
Do-It-Yourself Audit

PREFACE

This study arose from a number of factors. Firstly, the operating costs of public housing are generally shared between the federal and provincial governments. These costs have risen dramatically since the inception of the projects and a major part of the increase is due to the energy component.

Secondly, it has been accepted for some time that substantial savings can be made by more efficient use of equipment and control systems, but motivation to effect these savings is difficult to bring about.

Thirdly, it is now clear that major renewal of the building envelope or energy systems is so expensive as to be beyond any reasonable cost effectiveness based on energy savings.

Thus it appears that until building projects require regeneration on other grounds, energy conservation must take the form of better energy management. What was not known was the potential savings and costs of energy management and what strategy of implementation would be best suited to public housing.

The results are presented in two parts. This volume is a detailed summary of the work, its conclusions and recommendations. The second volume (Appendices A to E inclusive) contains supporting data, examples and other technical information and is available from

Canadian Housing Information Centre (CHIC)
National Office
Canada Mortgage and Housing Corporation
Montreal Road
Ottawa, Ontario
K1A 0P7

EXECUTIVE SUMMARY

This report describes a study undertaken into the energy upgrading problem for public housing in Canada containing twenty or more dwelling units and with centrally located utilities. The purpose was to report on the problem, to identify the potential for energy conservation, to develop a strategy for implementing energy upgrading, and to produce a database on the buildings involved.

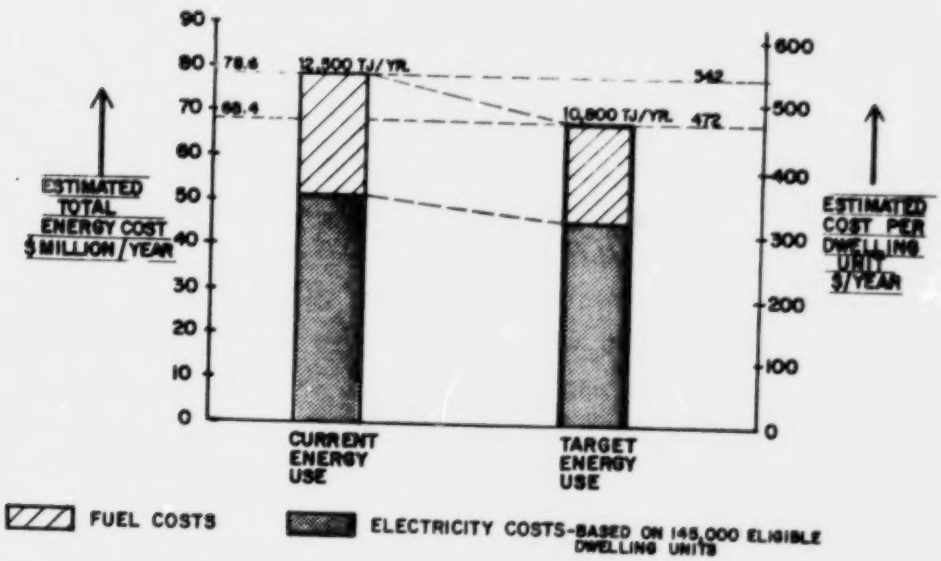
The study began with a survey of Canadian provinces and of other climatically similar countries, to learn of their activities in these areas. All provinces were found to be active, particularly with demonstration projects and insulation programs. Overseas government action was aimed primarily at the private sector, through financial and educational support programs. It was apparent that none of the governments which responded had undertaken a task of the magnitude of that faced by C.M.H.C. and the provinces in producing a comprehensive strategy for an entire public housing portfolio. There was also an almost universal absence of energy auditing and monitoring reported. Knowledge of current energy use by different building types and of savings realized by specific energy management action is therefore generally unavailable. There were relatively few reported training programs for building operators, managers and tenants. On the positive side, however, an abundance of tried and tested, often subsidized, technical changes were outlined.

The magnitude of the eligible building stock was estimated to be 1,650 projects and 145,000 dwelling units. Information about the projects was obtained by questionnaire, of which 1,026, or 62 percent of the eligible stock, were returned. Because of the information volume involved, a computerized management system was adopted. The result was a large and detailed profile of the housing stock with respect to the buildings, the systems within them, energy management action undertaken or planned, and energy use data. The latter came mostly from the more than five hundred Ontario Housing Corporation projects.

Site visits were then made to twenty-five buildings in different parts of Canada which were selected as representative of the building stock involved. From these visits, the state-of-the-art review and the experience of the consulting team, a list of energy management actions appropriate to public housing in Canada was developed. The number of opportunities to apply each action was estimated from the housing stock database and the consultants' experience.

More detailed energy analysis was performed on eight of the buildings using the SUMAC computer program. Energy targets for the eight buildings were calculated using a longhand procedure developed by the Ontario Ministry of Municipal Affairs & Housing. Again, the buildings were selected as representative of the eligible building stock. The analysis showed that energy use for these eight buildings was substantially lower than both the Ontario Housing Corporation averages and equivalent industry averages from the consultants' files. It was therefore concluded that these buildings were not representative of the total public housing stock. Despite relatively low energy use, all of the buildings showed potential energy savings, and this part of the study served to demonstrate the role of energy analysis in an evolving public housing energy upgrading program.

Estimated Energy Use And Potential Savings In Eligible Public Housing Stock



Based on the findings of the study and on estimates where adequate data were not obtained, potential annual energy cost savings of $10.2 million were calculated for the entire public housing portfolio which qualifies for the study. The recommended implementation strategy envisages a computerized information bank capable of delivering energy audits, targets and monitoring to all public housing projects in Canada, and of reporting to every level of management on all aspects of the program. Provinces and local housing authorities would be free to take action in whatever ways best suited their operating systems. But it is anticipated that training courses would be established for building managers and operators to help them fill their key roles in the program. The total anticipated cost for the program infrastructure, for training programs and for implementation of action in all 1,650 projects is expected to be up to $35 million over a five year period.

An Energy Information System For Public Housing in Canada

A pilot program of energy analysis and action in between 50-100 buildings from all major building types and in three or four regions of Canada is recommended to refine the estimate of potential energy cost savings and to test the viability of the recommended strategy. This pilot program would last for one year and cost between $158,000 and $220,000.

1. INTRODUCTION

Background

Federal government energy related subsidies in 1981 for the close to 200,000 public housing units across Canada were in excess of $30 million. Equivalent provincial subsidies were almost $25 million. Based on the experience of the consultant with a number of projects*, it is anticipated that savings of 15% - 20% may be attainable throughout the portfolio without resorting to major modernisation of the buildings involved.

C.M.H.C. do however realize that eventually a major Public Housing modernisation program will be required. In the interim energy upgrading of buildings is seen as a stop gap measure aimed at significantly reducing operating costs through no cost/low cost energy conservation measures and minor changes in operating strategies.

Objectives

The objectives of this study were:

- To report on the magnitude of the energy upgrading problem affecting buildings of twenty or more dwelling units, constructed under NHA public housing programs and with centrally located utilities.

- To base this report on:
  - the number and type of dwellings involved
  - their geographical distribution
  - their present energy usage
  - their types of heating systems
  - their existing operation and maintenance problems
  - the present international state-of-the-art with respect to energy upgrading of these types of buildings

. the potential for energy conservation without major alteration and modernisation of the building fabric
. other relevant factors.

- To develop a comprehensive and cost effective strategy for implementing the energy upgrading of medium- and high-rise buildings with centrally located utilities funded under Sections 40 and 44 of the NHA.

- To develop a database on the subject buildings which will be useful in subsequent phases of this work.

Tasks

In order to achieve these objectives, the project was divided into a series of tasks as follows:

- State-of-the-Art Review

  A survey of professional bodies and housing agencies in Canada and climatically similar parts of Europe and the United States to learn of their programs and activities, to identify gaps in currently available knowledge, and to recommend means of filling those gaps.

  A summary of findings from the State-of-the-Art Review is given in Section 2.

- Building Inventory Estimate

  Development of major generic building groups according to energy characteristics, and establishment of the number, size, age and geographic distribution of buildings falling in each group.

  A summary of findings from the building inventory estimate is given in Section 3.

- Individual Building Studies
  Physical surveys of up to thirty buildings selected as representative of the major generic groups, and computerized analysis of historical energy use records of eight of these buildings.

  A summary of energy management methods identified during the site visits is given in Section 5.

  Details of the computerized energy analysis and a summary of savings potential is given in Section 6.

- Analysis and Strategy Development
  Projection of the assembled data into estimates of potential energy cost savings and of likely expenditures necessary to realise those savings. Development of a comprehensive and rational plan of action for C.M.H.C. to tackle energy management throughout the public housing portfolio, together with a realistic time frame for the recommended plan.

  A summary of the method used to estimate potential savings is given in Section 7.

Project Team

The project was managed by the Technical Research Division of Canada Mortgage and Housing Corporation, and directed by an advisory committee which comprised representatives from both the public and the private housing sectors. The Organizatio Chart appears in Figure 1.1.

---

*Ministry of Municipal Affairs & Housing: "Energy Conservation Building Operations Demonstration for Gas-Heated High-Rise Multiple Unit Residential Buildings. May 1982 ISBN 0-7743-7507-8

Organization Chart

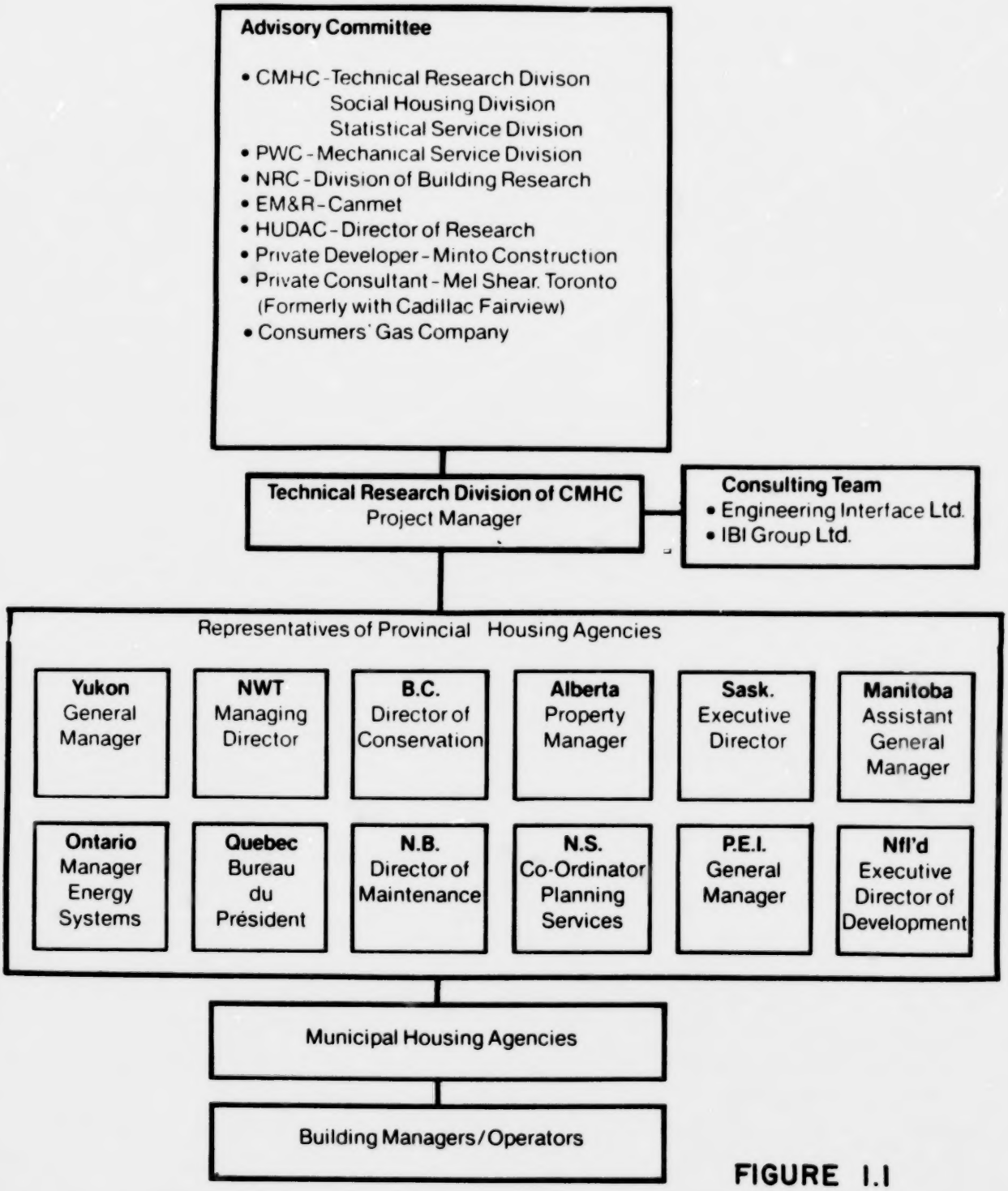

Advisory Committee
• CMHC - Technical Research Divison
Social Housing Division
Statistical Service Division
• PWC - Mechanical Service Division
• NRC - Division of Building Research
• EM&R - Canmet
• HUDAC - Director of Research
• Private Developer - Minto Construction
• Private Consultant - Mel Shear. Toronto
(Formerly with Cadillac Fairview)
• Consumers' Gas Company
Technical Research Division of CMHC
Project Manager
Consulting Team
• Engineering Interface Ltd.
• IBI Group Ltd.
Representatives of Provincial Housing Agencies
Yukon General Manager
NWT Managing Director
B.C. Director of Conservation
Alberta Property Manager
Sask. Executive Director
Manitoba Assistant General Manager
Ontario Manager Energy Systems
Quebec Bureau du Président
N.B. Director of Maintenance
N.S. Co-Ordinator Planning Services
P.E.I. General Manager
Nfl'd Executive Director of Development
Municipal Housing Agencies
Building Managers/Operators

FIGURE 1.1

2. STATE OF THE ART REVIEW

Scope and Method

A "state-of-the-art" review was undertaken in order to determine the extent of energy upgrading activities for multiple unit residential buildings in Canada and other climatically similar countries. Technical articles were also reviewed to learn of energy conserving measures being implemented and to note any gaps in current knowledge.

Provincial and Territorial housing corporations in Canada, together with foreign governments, building research agencies, and energy departments, were contacted for information. Ten housing corporations and ten foreign countries responded to the request with details of programs or policies aimed at conserving energy in multiple unit residential buildings.

A computer search was carried out by the Canadian Institute for Scientific and Technical Information (CISTI) for recent articles, reports and books focusing on the topics of energy management in buildings, apartment buildings and row housing. A list of approximately 120 titles was provided by CISTI, 64 relevant articles were requested and over 40 were received.

A list of the information sources received is presented in Appendix A.

Findings - Canada

Prince Edward Island

The P.E.I. Housing Corporation does not have a formal energy conservation strategy for its public housing buildings. However, the Corporation is involved in two projects which demonstrate

energy conserving practices. The first project is examining the feasibility of converting a 70-unit senior citizen project to a wood-fired (pellets or chips) heating system. The second project involves monitoring efficiency and effectiveness of air to air heat exchangers in senior citizens' housing constructed in 1980-81. Another energy saving initiative carried out by P.E.I. Housing Corporation is the addition of rigid insulation during siding retrofit of senior citizens' housing projects.

Nova Scotia

The Nova Scotia Housing Commission began implementing energy initiatives in public housing stock in 1977. At this time, design standards (including insulation and windows) were upgraded to incorporate energy conservation measures. Retrofit of older senior citizens' projects has been carried out by upgrading the insulation and adding storm windows and doors. This work was financed by the Federal home insulation program and involved approximately 85% of the existing projects.

The Commission is currently constructing a demonstration 30-unit senior citizens' project which is being fitted with solar panels for the purpose of preheating the domestic hot water supply.

Newfoundland and Labrador

Since 1967 the Newfoundland and Labrador Housing Corporation has been constructing housing units with separately metered independent furnaces or electric baseboard heating systems. This is seen as a self controlled conservation effort. In several older housing units the corporation has used CHIP to upgrade attic and basement insulation standards. A program of window replacement has also been started. On completion of these programs 867 units will have been reinsulated and 247 units will have had windows replaced.

Oil fired domestic hot water systems will also be phased out this year and replaced with separately metered electrically heated boilers. As well as fuel savings this conversion is aimed at eliminating costly servicing and maintenance of the oil fired units.

Quebec

The Societe d'habitation du Quebec has developed and is currently implementing a comprehensive energy conservation and preventative maintenance program. As part of the program the Societe has adopted specific measures for new buildings as outlined by National Research Council. These measures include: upgrading of building design standards, stop start control of ventilation systems and preferential use of natural and fluorescent lighting. Included in the Societe's portfolio are non-profit and co-operative run buildings as well as the municipally managed public housing projects. Various conservation activities are currently being undertaken within each of these sectors with the Societe acting as liaison to ensure a uniform approach. Two case studies have also been undertaken by the Societe to demonstrate conservation measures in a student residence and a prototype single family dwelling. As part of this program building energy profiles will be analysed and a public awareness campaign stimulated. In the future the Societe hopes to develop prototype prefabricated housing units.

Saskatchewan

The Saskatchewan Housing Corporation has been actively involved with the promotion and implementation of energy conservation in the residential sector for many years. Some examples of major provincial initiatives include the "warm-up" program for existing housing and the Saskatchewan Conservation House. The Saskatchewan Housing Corporation has been involved with an exploratory retrofit housing program, with the technical assistance of the Saskatchewan Research Council.

Saskatchewan Housing Corporation also runs the "Help Program" which is concerned with improving the standards of vapour barriers and insulation.

Alberta

The Alberta Housing Corporation has a number of programs aimed at conserving energy. These include upgrading insulation, lighting improvements, timeclocks and other new controls, and education and promotion for tenants with respect to energy conservation.

Yukon/North West Territories

Although there are no mid or high-rise public housing buildings in these jurisdictions, the Yukon and North West Territories Housing Corporations have undertaken a number of energy conservation projects. CHIP has been used during the past few years to upgrade attic and basement insulation along with caulking and weatherstripping on several housing units. Other energy conservation initiatives include experimental housing units and retrofit demonstrations. The Yukon Housing Corporation is also working closely with C.M.H.C. to develop the housing design most suitable for the northern climate.

British Columbia

The British Columbia Housing Management Commission has an Energy Conservation Program which has the objective of achieving the optimum in energy conservation and energy efficiency through effective management. The program involves education of staff and tenants (an information package for building managers is available), energy audits of selected Commission buildings and information meetings with all staff groups in the Province.

Ontario

The Ontario Housing Corporation has implemented an Energy Conservation Program which emphasizes auditing of energy use. The Corporation set up the Energy Consumption Reporting System (ECRS) which records and analyzes energy use in 700 apartment projects in the Province. Opportunities for energy conservation are defined in three main areas; day-to-day operations and good maintenance; upgrading of buildings and equipment; reduction in energy used by tenants. A number of energy saving initiatives have been investigated by means of a feasibility study, trial demonstration/installation, and monitoring. This testing has led in some cases to the development of "standard" specifications. Many buidings have been retrofitted for insulation, lighting, ventilation, saving devices, and ramp heaters. Technical demonstration projects have been undertaken, including computerized control of an electrically heated high-rise building.

The province has also funded a series of demonstration projects for public and private sector buildings aimed at establishing the potential for energy management through energy auditing and monitoring in conjunction with staff training.

Findings - United States

General

Federal assistance is made available to public housing authorities through the Department of Housing and Urban Development (H.U.D.). It is understood that H.U.D.'s major involvement with public housing started in the 1960's when Federal contributions were made to pay off a portion of the construction mortgages for approximately 1,200,000 public housing units. In the mid-1960's a congressional decision was also made to allocate funds, through H.U.D., to cover a portion of building operating costs.

Recently a building modernisation program has been started by H.U.D. which also includes energy conservation retrofits.

An energy conservation work booklet has also been developed which allows individual building operators to identify potential energy conservation measures and associated payback periods. Federal funding assistance is in theory available for measures with a payback period of 15 years or less. The booklet was released in 1981 and to date savings have not been monitored.

H.U.D. also recognises that considerable energy savings can be low cost through operational and maintenance changes.

To illustrate this principle, a demonstration project in Trenton, N.J. was commissioned. Findings so far suggest that significant savings can be made, and capital recovered in less than two years.

Investor run utilities in the United States have also been Federally mandated to conserve energy. To this end, utilities in a number of States are actively involved in energy management programs. Some utilities also provide low interest loans for approved conservation measures.

New York State

The main thrust of state funded programs is aimed at low cost/no cost conservation measures such as upgrading boiler controls and weatherstripping. In some cases replacing incandescent lighting is also seen as a priority. A public awareness campaign "Saving Power Program" which in some cases includes free house audits and low interest loans is operated by the New York Public Service Commission. Two studies to assess the energy conservation potential in low rent housing in middle income dwellings have recently been carried out under the auspices of the Division of Housing and Community Renewal. As yet, the recommendations from the studies have not been acted upon. The New York State Energy Research and Development Agency reports that to date no standards for buildings' performance have been established. In the private

sector a number of companies are offering shared-savings financing for home owners and independent housing authorities. Under these schemes a user receives free conservation equipment, installation and maintenance. Capital outlay and other costs are recovered by taking a percentage of the dollar savings. This form of financing is also gaining popularity in New Jersey and Rhode Island.

Washington, Oregon,
Idaho, Montana

A number of general energy management programs for residential buildings are operated and funded by the investor run utilities in this region as part of the general Federally mandated program for all utilities. Federally sponsored boiler workshop programs and low interest insulation grants are also available. Washington State is currently developing a state building energy management scheme which will identify energy savings potential in public buildings.

Michigan

The Department of Energy in Michigan State operate an energy information telephone hot line. In addition, a number of state sponsored energy management programs are currently underway. None however is aimed at the public housing sector.

North Dakota

No financial assistance programs are currently available for residential buildings in North Dakota. There is, however, a state energy office information program. A series of insulation workshops are also being organized. Each investor utility in the State has been Federally mandated to provide energy conservation services and these include low interest loans and energy auditing schemes.

New Jersey

Two main state funded energy conservation audit programs have been

started although these are aimed at public rather than residential buildings. Energy conservation in the residential and public housing sectors is handled by independent housing authorities and the investor run utilities. Currently, a substantial auditing program funded by these utilities is underway to determine potential savings in a number of sectors, including housing. A scheme of low interest loans is also operated by utilities.

Findings - Europe

Sweden

Financial assistance has been available in Sweden since 1974 for improvement of heating and ventilation systems, for individual metering, and for installation of new forms of heating. Interest free subsidies are granted on loans to multi-family housing.

A campaign was initiated in 1975 by the Swedish Government named EPD (Energy-related Prototype and Demonstration Activities), with the purpose of informing and demonstrating to homeowners and caretakers of small and medium-sized apartment buildings that have oil-fired heating systems how energy consumption can be reduced by simple means. Trained EPD advisors run information sessions and demonstrate tuning of boilers in participants' boiler rooms. The campaign has reached approximately 12% of all boiler plants in small apartments.

In all Scandinavian countries, working groups have been established to study health aspects related to indoor air quality.

Norway

In Norway, the "Housing Bank" initiated a program of energy conservation loans to encourage energy saving by extra insulation of existing residential buildings. This program, however, was

discontinued after one year because of financial restraints. A research program was set up to measure energy consumption in older residential buildings before and after improving the level of insulation. Approximately 58% of theoretically calculated savings were actually gained. In 1979-1980 the government started an information campaign for energy conservation in an effort to change consumers' knowledge about and attitudes toward energy conservation.

Denmark

Government subsidies are available in Denmark for the cost and installation of energy conservation measures suggested or approved by an energy consultant. Subsidies in the form of tax relief have also been provided. The government would like to increase use of controls on technical plants and to stimulate interest among consumers in the individual measurement of heat consumption. Laws have been developed to promote district heating.

Finland

Finland provides financial assistance for heating and ventilating system improvements. Encouragement of individual metering has also been recognized as a means of reducing energy consumption. Boilers have been designed for conversion to a combination of electric and wood chip firing. District heating is also being promoted by the government.

U.S.S.R.

Much attention is being paid to providing indigenous low cost natural gas to existing buidings. During the heating season all houses and public premises are heated to 22 degrees Celcius. Prefabricated, factory assembled units, "volume housing", incorporating standard design features comprise the majority of modern multiple unit residential buildings.

United Kingdom

A formal energy committee has been operating in the U.K. since 1977. A major task of this committee, in liaison with the Department of Energy and professional bodies, has been to produce a comprehensive building energy code which provides guidance towards energy conserving design of buildings and services. Government subsidies are also available for part of the installation cost of energy conservation measures approved by an energy consultant. Subsidies in the form of tax relief have also been provided. However, many of the energy conservation initiatives have been left to professional bodies and the 400 local housing authorities. Among the activities promoted by the professions is mid-career training of members and the establishment of impartial local energy conservation information and advice centres.

European Economic Community

Discussion about a future Energy Conservation Agency is of considerable interest to the EEC, but at this stage the full Council of the EEC has not had an opportunity to consider the issue in detail.

In the Netherlands, particular attention is being applied to air renewal and leakage rates. It appears that, while Sweden and here in Canada, three to four air changes per hour are provided, most North European countries average around fourteen air changes per hour.

In France an external insulation program of a number of older apartment buildings is being undertaken using a system of prefabricated panels.

Other innovative projects include a West German system which reclaims waste water heat by an electrical heat pump and uses it to provide domestic hot water.

Technology

Review of information provided by Canadian housing corporations and other countries, and of technical articles, indicates a wide variety of technical and management approaches to energy conservation. These are mentioned below, and outlined in greater detail, together with reference to a numbered information source, in Appendix A.

1. Boiler Improvements
2. Heat Storage
3. Heat Recovery
4. Added Insulation
5. Temperature Reductions
6. Individual Metering
7. Alternative Heating Sources
8. District Heating
9. Ventilation Changes
10. Heat Pump Applications
11. Sealing and Weatherstripping
12. Heating System Maintenance
13. Domestic Hot Water System Changes
14. Improved Windows
15. Automatic Controls
16. Delamping and Relamping

Discussion

The ten responses from Canadian provinces were directed primarily at social housing programs, and are summarized in Table 2.1. Responses from overseas related more to the general problem of energy conservation in all multiple unit residential buildings, and these are summarized in Table 2.2 included at the end of this section. While the samples are not large, some interesting trends do emerge from these tables. Among the Canadian provinces:

- most report demonstration projects
- most have undertaken wide scale building insulation programs
- only two report staff education programs while two report programs to encourage energy conservation among tenants
- only two report energy auditing and monitoring programs
- only four report wide scale retrofit programs other than building insulation.

Among the overseas respondents:

- all reported financial incentive programs for the private sector
- half were involved in education programs to encourage energy conservation
- only three reported a wide scale energy auditing and monitoring program
- only one has enacted energy conservation related legislation.

The major, almost universal gap in current knowledge drawn from this part of the study is the general absence of wide scale and consistent energy auditing and monitoring activity. As a result, current energy use levels by the various types of multiple unit housing are unknown and, more seriously, effectiveness of the many different programs which have been undertaken cannot be readily assessed. It is noted that the research program in Norway found that only 58 percent of calculated potential energy savings from upgrading building insulation were realized, underscoring the importance of tracking results.

A second noteworthy outcome from this review is the relatively low incidence of reported education and training programs for building owners, operators and tenants. The demonstration projects in Ontario indicated that training of motivated people, in conjunction with energy auditing and monitoring, can achieve and maintain energy savings on a wide scale with relatively little capital investment.

The third major finding from this part of the study is the abundance of technical data on changes which can be made to buildings and their energy using systems. It is thereby concluded that most of the technical knowledge necessary for energy conservation in Canadian social housing exists, and that this study should focus on means of identifying where changes should be applied (auditing) of effectively implementing and maintaining them (action) and of tracking resultant energy savings (monitoring).

	Multiple Building Insulation Programs	Demonstration Projects	Multiple Building Retrofit Programs	Staff Training	Tenant Education	Energy Audits & Monitoring	Improved Design Standards
Prince Edward Island	x	x					
Nova Scotia	x	x					x
Newfoundland and Labrador	x		x				
Quebec		x					x
Saskatchewan		x	x				x
Alberta	x		x		x		
Yukon/NWT	x	x					x
British Columiba				x	x	x	
Ontario	x	x	x	x		x	x

Table 2.1

ENERGY CONSERVATION PROGRAMS AND PROJECTS REPORTED
BY CANADIAN PROVINCES AND TERRITORIES

	Financial Support Programs	Education Programs	Energy Audits & Monitoring	Energy Conservation Legislation	Technical Research & Development
United States	x	x	x		x
Sweden	x	x			
Norway	x	x	x		
Denmark	x			x	
Finland	x				x
United Kingdom	x	x	x		x

Table 2.2

ENERGY CONSERVATION PROGRAMS AND PROJECTS
REPORTED BY U.S.A. AND OTHER COUNTRIES

3. BUILDING INVENTORY ESTIMATE

The building inventory estimate was undertaken in order to develop a profile of the total number and type of buildings qualifying for this project. This profile was then used, in conjunction with the detailed questionnaire survey described in Section 4, to help estimate the magnitude f the energy upgrading problem. Information was obtained from a specially prepared computer printout from the central files at C.M.H.C's National Office.

Classification of Buildings

In total, approximately 1800 social housing projects were found to qualify for this study. The data included in the C.M.H.C. files allowed the following tabulations to be made:

- Total public housing stock by degree day zone
- Public housing types by degree day zone
- Public housing stock by degree day zone and by province
- Housing type by province.

Ten housing types are identified in the C.M.H.C. categorization system based mostly on configuration of dwelling units (row, back to back, apartment, etc.), and on building height. Hostels and hostels with nursing services are listed as separate categories.

Climatic classification was based on conventional 18° Celcius based degree day zones as follows:

Zone I	less than 3,500 degree days
Zone II	3,500-5,000 degree days
Zone III	5,001-6,500 degree days
Zone IV	6,501-8,000 degree days

Summary of Findings

The tabulations prepared during this part of the study are provided in Appendix B, and summarized as follows:

- Total Stock by Degree Day Zone
  - Zone II contains approximately 70 percent of all units
  - Zone III contains approximately 25 percent of all units
  - Zones I, IV and V together contain only 5 percent of all units.
- Housing Types by Degree Day Zone

  In general, housing types are divided proportionately among the degree day zones. Most back to back row housing units are found in Zone II, but no particular significance is attached to this finding.

- Total Housing Stock by Province

  The total eligible public housing stock, according to C.M.H.C. files, amounts to approximately 154,000 dwelling units. They are located as follows:

Ontario	55 percent
Quebec	18 percent
Manitoba	6 percent
Alberta	4 percent
British Columbia	4 percent
Other provinces and territories	13 percent

- Housing Stock by Building Type

  Approximately 47 percent of all units are in apartment buildings with elevators. 25 percent are row housing units, and the remainder are in walk-up buildings.

- Building Type by Province

  77 percent of all units in high-rise apartment buildings (11 storeys +) are located in Ontario, while 93 percent of row housing units with back to back corridors are found in Ontario. Otherwise, units are divided proportionately among the provinces and territories.

Estimate of Building Stock for this Study

There is some concern that the files may not contain all projects built during the past two years, while some projects, which were approved but never built, may be included. There is also a discrepancy between Ontario Housing Corporation records and the C.M.H.C. files with respect to the number of row housing units in Ontario which qualify for this study. Studies are underway in this province to clarify this situation.

For the purpose of this study, 1,650 out of the total estimated 1,800 projects, and 145,000 of the 154,000 dwelling units have been used to form the basis of analysis.

4. QUESTIONNAIRE SURVEY

Scope and Method

The questionnaire survey was undertaken in order to provide more information about the public housing projects which were eligible for this study. The questionnaire was designed specifically for the study, and allowed for up to 223 pieces of information to be recorded for each project in forty-two separate categories. A copy of the questionnaire and a summary of information committed to the database are attached as Appendix C. The questions covered the following broad areas:

- Building description (address, number of units, number of floors, construction, etc.)
- Space conditioning (type, energy sources, means of control, ventilation, etc.)
- Domestic hot water (type, energy sources, etc.)
- Additional energy systems (air conditioning, snowmelting, lighting etc.)
- Building operations (operator's experience, maintenance practices etc.)
- Energy management (methods being used, methods suggested)
- Energy data (building area, historical energy use etc.)

Questionnaires were sent to provincial and territorial officials, who passed them on to individual building managers. After completion, they were returned to the consultant via the provinces and territories. Procedures involved in development, distribution and retrieval of questionnaires are shown diagrammatically in Figure 4.1.

Questionnaire Flow Diagram

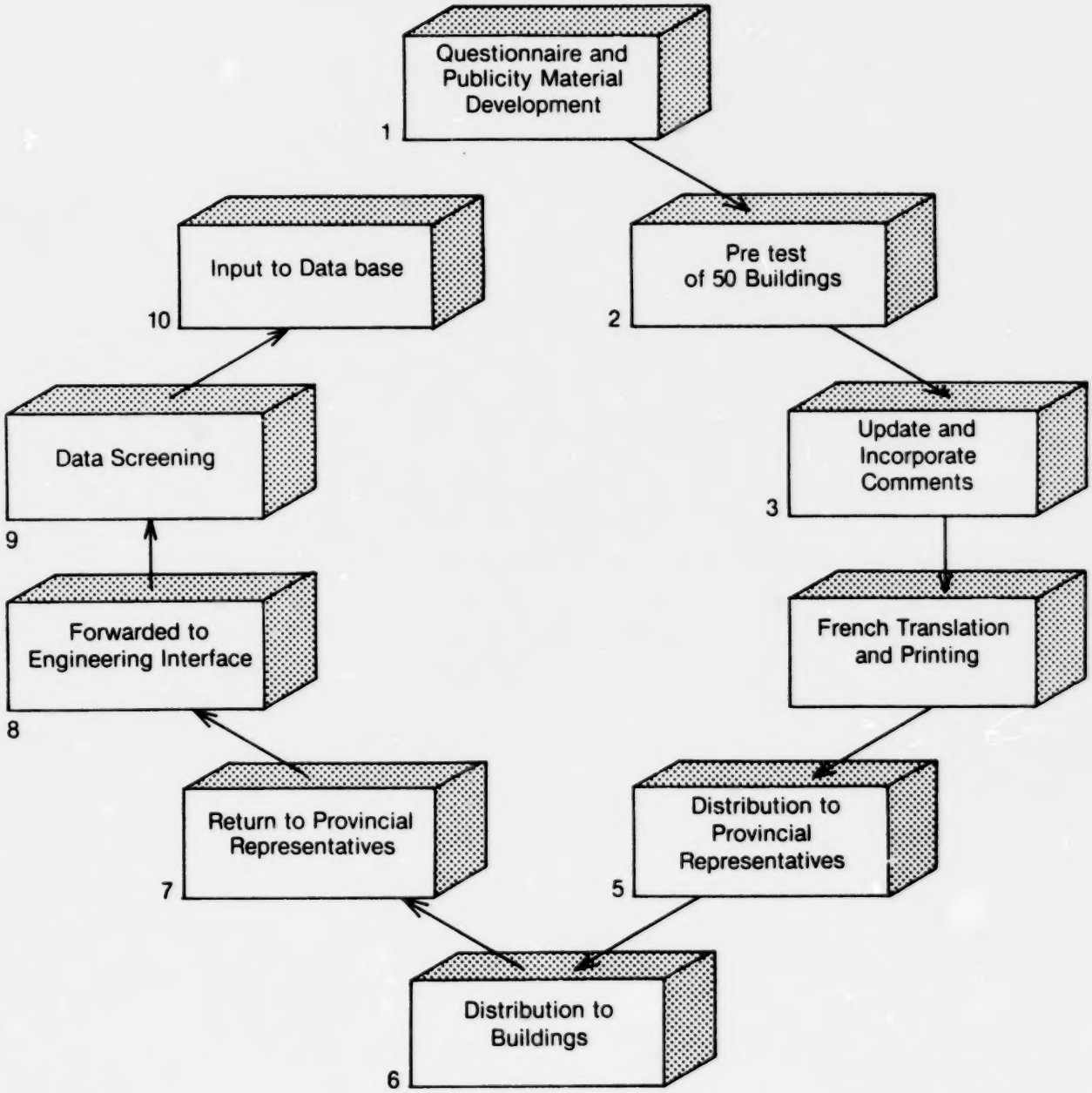


FIGURE 4.1

Information obtained from the questionnaires was needed to:

- Establish a simple set of generic building groups which would together contain all eligible public housing projects. Generic groups would be defined according to anticipated types of energy management methods and implementation procedures.
- Allow current energy use of each of these groups to be estimated
- Provide a database of building information which would be useful in later stages of the public housing upgrading program.

Questionnaire Response

1026 completed questionnaires were returned in time to be included in the study. This represents approximately 55 percent of the maximum possible 1800 qualifying projects, or 62 percent of the 1650 projects which were estimated in Section 3 to form the basis for analysis. Table 4.1 shows the number of responses relative to the estimated number of eligible projects for each province.

	No. of Returned Questionnaires	Estimated No. Eligible Projects	Percent Response
Prince Edward Island	6	6	100
Newfoundland	7	29	24
Nova Scotia	-	133	0
New Brunswick	11	43	26
Quebec	149	345	43
Ontario	622	622	100
Manitoba	82	160	51
Saskatchewan	23	9	24
Alberta	65	130	50
British Columbia Yukon	61	85	72
North West Territories	N/A	—	—
	1,026	1,650	62.2

TABLE 4.1 NUMBER OF QUESTIONNAIRES RETURNED BY EACH PROVINCE

Total Public Housing Stock With Central Heating Plant By Degree Day Zone

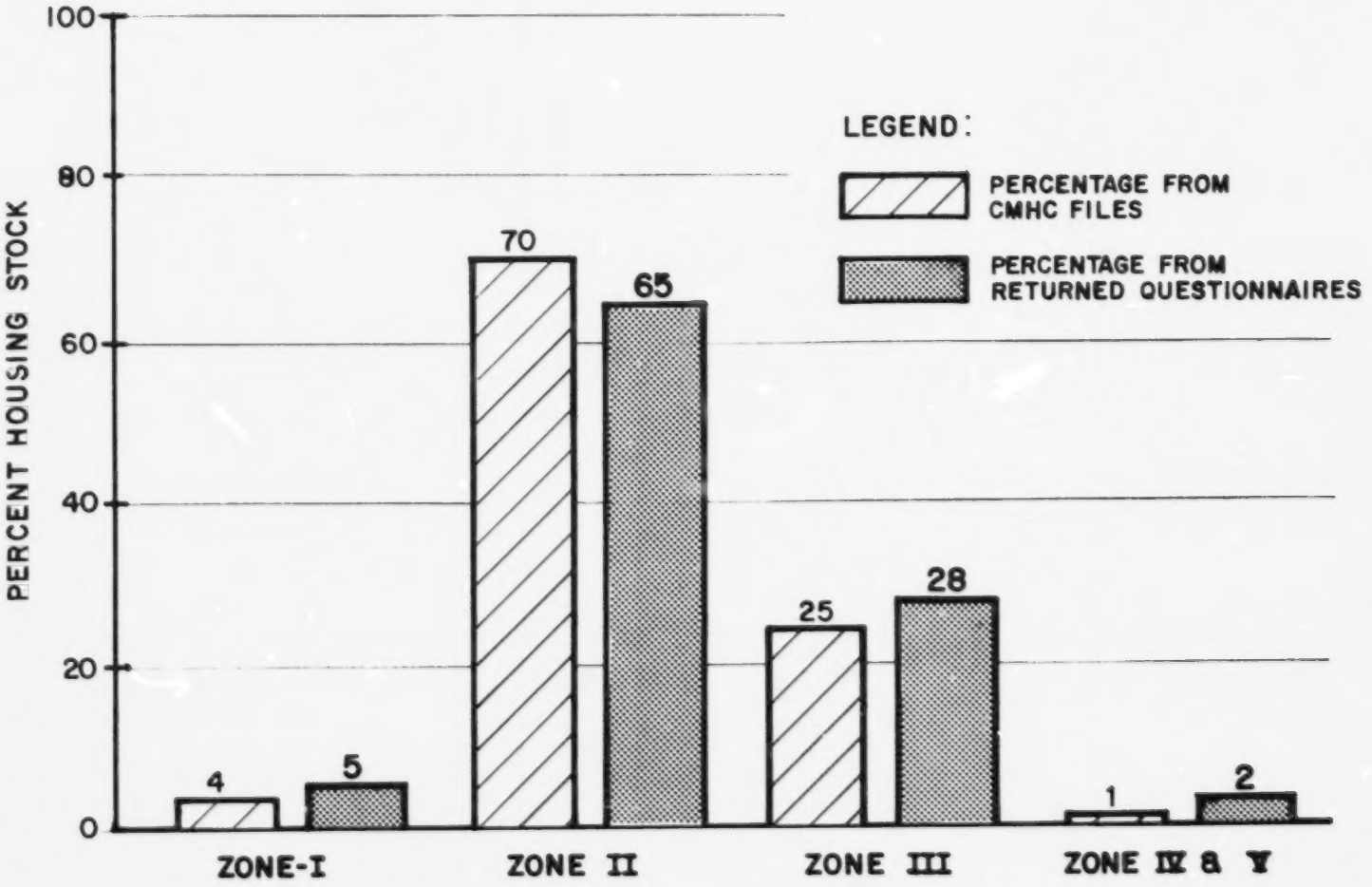


FIGURE 4.2

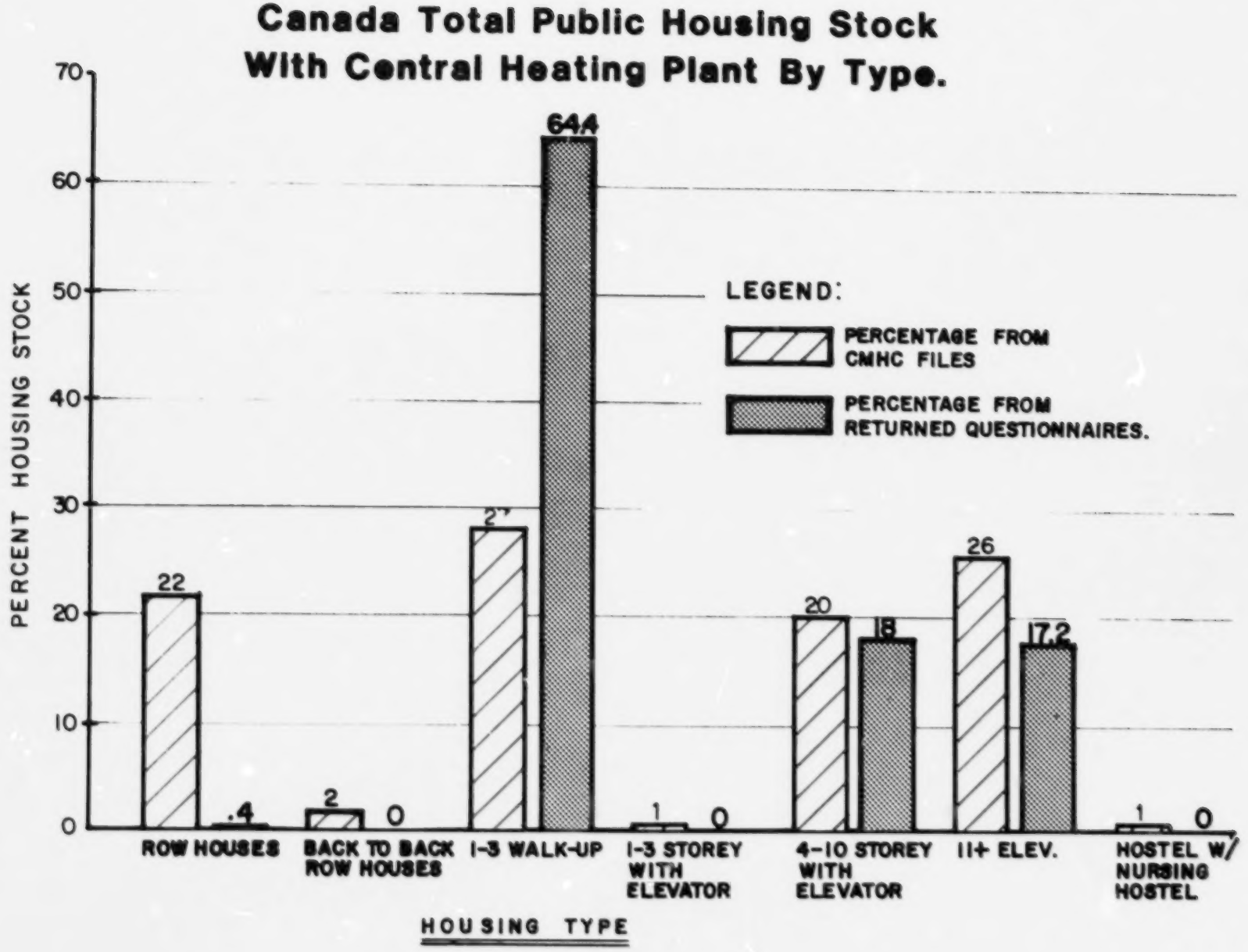

Canada Total Public Housing Stock
With Central Heating Plant By Type.
PERCENT HOUSING STOCK
70
60
50
40
30
20
10
0
LEGEND:
PERCENTAGE FROM CMHC FILES
PERCENTAGE FROM RETURNED QUESTIONNAIRES.
22
.4
2
0
27
64.4
1
0
20
18
26
17.2
1
0
ROW HOUSES
BACK TO BACK ROW HOUSES
1-3 WALK-UP
1-3 STOREY WITH ELEVATOR
4-10 STOREY WITH ELEVATOR
11+ ELEV.
HOSTEL W/ NURSING HOSTEL
HOUSING TYPE

FIGURE 4.3

The overall response is considered to have been very good, and indicates a high level of interest in the project by the provinces. It also represents a lot of hard work given readily by provincial and local housing representatives.

The response was further analyzed from the standpoint of compatibility with data developed from C.M.H.C. files in Section 3. Figure 4.2 shows very similar climatic distributions, while Figure 4.3 indicates that a disproportionately high number of responses came from 1-3 storey walk-ups, with little or no response from row housing. This latter anomaly results from the discrepancy between C.M.H.C. and provincial files mentioned in Section 3. The high representation of walk-up buildings introduces a bias in favour of low-rise projects but is not felt to distort the subsequent analysis.

Only Ontario Housing Corporation was able to provide building area and energy use data and these were incorporated in the database for over 500 buildings.

Data Handling

The returned questionnaires provided close to a quarter of a million separate pieces of information. It was therefore decided that computerized data handling was necessary. With an eye to the future, it may be desirable to add projects to this database or to obtain more information from projects which returned questionnaires. The opportunity was therefore taken to demonstrate the capabilities of database management software which has been developed by a number of different companies to allow convenient storage, retrieval and analysis of large data sets.

There are several types of database management system. The most recently developed type is termed "relational," since it handles information in the form of tables. For the type of data handling needed for this study, relational database management was determined to be the most suitable type. At the time of the study, the Oracle system was

available through a service bureau in Canada, and was in use by several organizations, including the National Research Council. The Ingres system was a good alternative, having some desirable features unavailable with Oracle, but was not immediately available in Canada. Time considerations resulted in adoption of the Oracle system for this study.

The attributes of Oracle, and of other relational systems are as follows:

- Low cost and short development time to establish or modify an accessible database and its associated programs
- Uses a high level English based command language for storing, retrieving, updating and analyzing data; no special programming skills are necessary
- Incorporates security features to restrict access to specified parts of the database
- Includes a report writer to simplify the production of repeated reports

Information from the questionnaires was committed to three IBM-readable magnetic tapes which will be handed to C.M.H.C. at the end of this study. The tapes were then read into tables programmed into Oracle.

Findings

A response count for 204 questions from the questionnaire is attached as Appendix C. The following is an illustration of information that may be drawn from this body of data:

- 77 percent of projects were built between 1971 and 1980
- 65 percent of projects contain 59 dwelling units or less
- 83 percent of projects are more than 75 percent occupied by senior citizens

- 90 percent of projects are double glazed
- 66 percent of projects are electrically heated; 32 percent are heated with natural gas; 3 percent are heated with fuel oil
- 68 percent of heating boilers are atmospheric; 48 percent of these are manufactured by Raypak
- 60 percent of projects have electrically heated domestic hot water
- 27 percent of projects have incandescent corridor lighting; 5 percent have incandescent garage lighting
- 68 percent of building operators have worked for 3 years or more in the same building
- The greatest incidence among suggested energy management measures (37 percent of respondents) was to stop tenants wasting energy.

Generic groups of building were established by inspection of the database as follows:

- All-electric; medium and high-rise
- All-electric; low-rise
- Fuel heated; medium and high-rise
- Fuel heated; low-rise
- Hybrid heating; medium and high-rise
- Hybrid heating; low-rise

Hybrid heating is electric space heating with fuel heated domestic hot water and/or corridor ventilation. The groupings are made based on anticipated energy management methods and implementation procedures. While a number of methods are common to all three forms of heating, each has a major, unique area of study as follows:

- All-electric - electrical billing demand control
- Fuel-heated - heating boilers and system maintenance and control
- Hybrid heating - both the above plus energy substitution

It was noted that there are insufficient fuel oil heated buildings to justify separating them from natural gas heated building as an independent group. The further subdivision according to building size is based on the expectation of different implementation procedures, with the larger buildings justifying a greater level of effort and expenditure than would the smaller ones. The distribution of projects and dwelling units among these six generic groups is shown in Figure 4.4.

The following energy performance averages were drawn from energy use data and floor area records provided for the more than five hundred Ontario Housing Corporation projects:

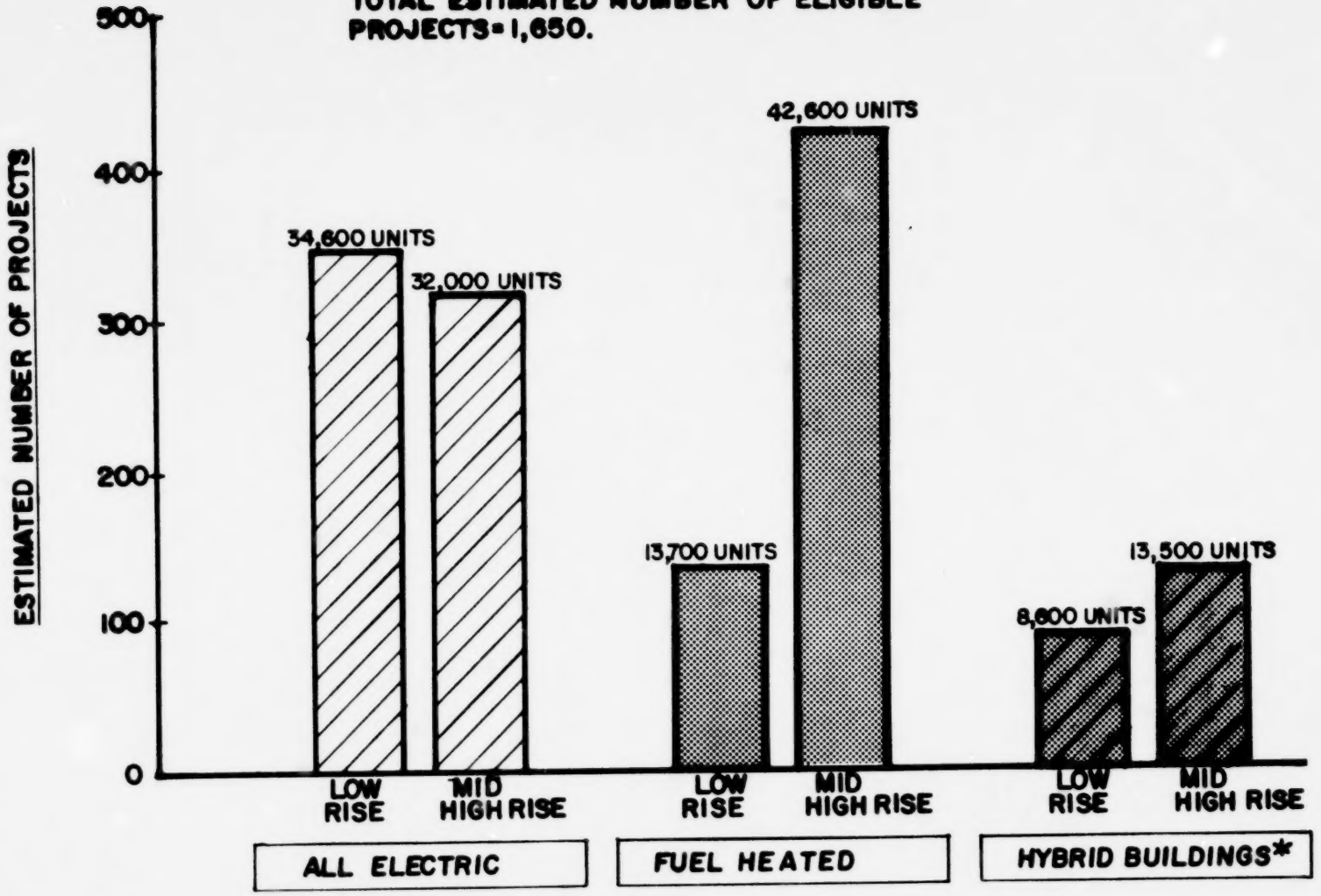
Building Type	Current Average Energy Use MJ/sq.m./Year
All Electric	734
Fuel Heated	1,708
Hybrid Heating	1,100

These figures are felt to be statistically meaningful for Ontario in light of the sizes of samples involved. In absence of equivalent data from other provinces, it was necessary to use these figures as a basis of analysis for Canada as a whole, even though it is likely that energy efficiency varies among provinces according to age of the building stock and level of energy management activity.

The figures also provide a preliminary indication of energy management potential among the fuel heated stock. All-electric buildings do not experience boiler losses, and are therefore expected to purchase less units of energy (although at a higher unit cost) than are fuel heated buildings. If 70 percent of average energy use in all-electric buildings is attributable to heating and domestic hot water, which are subject to boiler losses in fuel heated buildings, and if average seasonal boiler efficiency is 65 percent, then the equivalent energy use for the fuel-heated building, based on the all-electric average, would be approximately 1,050 MJ/sq.m./yr. The recorded average is 68 percent higher than this, implying unusually high energy losses in the fuel heated building stock.

SUMMARY OF DWELLING UNITS BY GENERIC BUILDING GROUP

TOTAL ESTIMATED NUMBER OF ELIGIBLE PROJECTS = 1,650.



* ELECTRIC SPACE HEATING, FUEL HEATED CORRIDOR VENTILATION, ELECTRIC / FUEL HEATED DOMESTIC HOT WATER

FIGURE 4.4

5. ENERGY MANAGEMENT METHODS

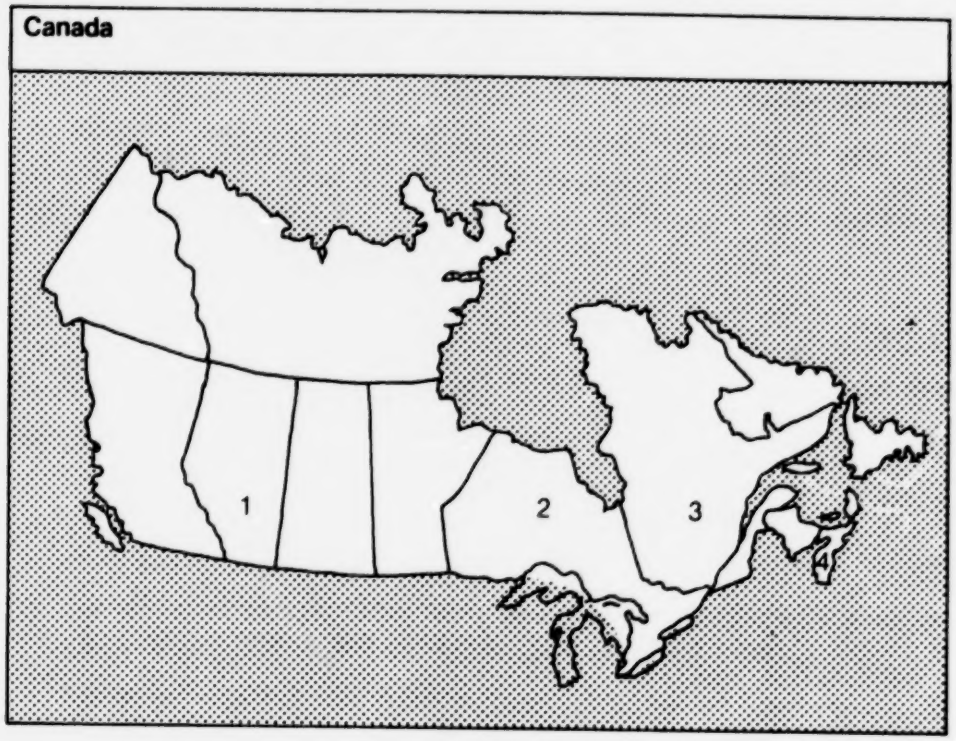
Scope and Method

Site visits were made to twenty-five buildings selected to be representative of the eligible public housing stock. The purpose of the visits was to identify appropriate energy management actions and means of implementation, and to help produce an estimate of the number of opportunities to be expected for each action in the eligible Canadian public housing portfolio. Site visits were all conducted by senior registered professional engineers. To ensure a consistent approach, an energy checklist was developed and is included in Appendix D.

Building Selection

At least one representative example of each of the six generic building groups derived from the database analysis in Section 4 was visited. Building selection was also biased to reflect dominant regional housing types identified during the search of C.M.H.C.'s public housing files (Section 3). Therefore, in the Maritimes and Quebec, attention was focused on low-rise walk-up apartments and medium-rise buildings. In Ontario, emphasis was placed on high-rise apartments, which are the dominant public housing type. In the western provinces, high-rise and walk-up apartments were visited. Possible climatic and regional differences in design, construction and operation of public housing were also considered, with buildings chosen from four provinces and covering the two major Canadian degree day zones. Fuel-heated medium- and high-rise projects were also emphasized, since it is anticipated, in the experience of the consultant, that this is where the biggest potential for savings will be found. Figure 5.1 shows the geographic distribution of buildings that were visited, and Table 5.1 details numbers of projects and dwelling units according to generic building group and location.

Locations of Site Visits



	Region	Buildings	Degree Day Zone
1.	Alberta	4	III
2.	Ontario	14	II & III
3.	Quebec	5	II & III
4.	Nova Scotia	2	II

FIGURE 5.1

Building Group	Number Visited	Number of Dwelling Units	Location
All Electric			
Low-Rise	2	46	Mississauga, Sudbury
Mid/High Rise	2	323	Mississauga, Quebec City
Fuel Heated+			
Low-Rise	3	394	Toronto, Halifax
Mid/High Rise	14	2,921	Toronto, Sudbury, Dartmouth, Montreal, St.Laurent, Lachine, Edmonton
Hybrid*			
Low-Rise	1	263	Toronto
Mid/High Rise	3	586	Hamilton, Sudbury, Montreal
TOTAL	25	4,533	

Key

+ includes oil heated buildings
* electric space heating, fuel domestic hot water and/or corridor ventilation heating

TABLE 5.1

Summary of Building Types Visited and Locations

Energy Management Methods Identified

The following is a summary of energy management methods which apply to Canadian public housing. Opportunities identified for each project visited are summarized in Appendix D. The number of projects to which each measure applies was estimated from the building database (Section 3), from the site visit findings and from the experience of the consultant in other similar buildings. An asterisk code is provided alongside each measure to denote the percentage of projects to which the measure is expected to apply as follows:

0% - 10%	*
11% - 30%	**
31% - 50%	***
51% - 75%	****
76% - 100%	*****

. Heating Boilers

1. Improve boiler combustion - ***.

   This is a service function, but building operators should be provided with analyzers to check efficiency themselves. In extreme cases, the burner may need to be replaced. The objective is to adjust the air to fuel mixture to obtain the best possible seasonal boiler efficiency.

2. Improve boiler maintenance - ***

   Again a service function, building operators should be trained to do some of the work themselves and to ensure that contractors do a good job. In some cases, boiler refurbishment or addition/replacement of instruments will be necessary. The purpose is again to get the best seasonal efficiency out of boilers, and to allow their operating conditions to be monitored.

3. Adjust boiler control setpoints - **
   This is simply a matter of training operators in how to monitor control performance and to adjust existing controls to minimise fuel loss associated with short cycling on and off.

4. Modify boiler controls - **
   Boiler control modifications are generally intended to reduce short cycling and involve addition or replacement of gas valves and controllers.

. Heating Systems

5. Insulate hot pipework - *
   In general, 1 inch thick insulation should be added to uninsulated heating pipework in areas where heat currently being lost from the pipes is not useful to the building (such as in a heated garage). This applies particularly where heating pipes run alongside domestic cold water pipes.

6. Add automatic outside temperature compensation control - *
   New controls are provided to automatically raise and lower heating water temperatures according to outdoor temperature, thereby reducing the risk of overheating in mild weather. Most buildings with hot water heating systems already have this type of control.

7. Install automatic temperature setback - **
   This controller is added to hot water heating systems to automatically reduce water temperature during periods when ventilation fans are shut down and/or lower temperatures are acceptable (overnight).

8. Adjust/replace heating controls to avoid overheating - ***
   The operator in every building with hot water heating systems

should be trained to log supply water and outdoor temperatures every day. By graphing the results, correct operation can be verified and controls can be adjusted to provide consistent year round indoor temperatures. Fuel savings in excess of 20 percent have been made in several buildings simply by making better use of heating system controls. In many instances it has been found necessary to replace malfunctioning controls.

9. Provide zone controls - *

   In most buildings, well managed outside temperature compensation controls on a well maintained heating system provide optimum energy performance, and addition of thermostatic valves for individual suites has not been found cost effective. In a few buildings, addition of zone controls is worthwhile, to allow independent control of north and south building faces or of upper and lower parts of the building, thereby preventing zone overheating.

10. Improve heating system maintenance - **

    Most hot water heating systems require some degree of refurbishment. Flow balancing, water treatment and cleaning of heating elements are among the methods which the building operator should use to obtain uniform temperatures throughout his building.

11. Upgrade building envelope locally to overcome cold spots - **

    The building operator should be trained to look for building envelope problems in cold areas of his building, especially with hot water heating where the rest of the building has to be overheated to provide comfortable conditions in the cold area. Gaps in the wall behind baseboards and radiator covers, leaky windows and balcony doors, and degraded roof insulation are among culprits from the past. Where heaters in some units are genuinely short of capacity, local interior storm windows should be added.

. Domestic Hot Water Systems

12. Reduce water temperature - *****

Most buildings have potential for lowering the domestic hot water temperature to reduce heat losses from pipework as well as energy used directly to provide hot water. Normally adjustment of controllers is all that is required, although addition of blending valves may be necessary where storage and recovery capacity are limited. Lower temperatures also slow the rate of galvanic corrosion in galvanized pipes.

13. Install low flow devices - **

Low flow shower heads and tap aerators always seem to be a good idea, but rarely live up to their apparent potential. Most residents of public housing are senior citizens who do not normally take many showers. Building operators should be trained to survey current flow rates and hours of use of showers and taps before any commitment is made to replace existing heads.

14. Balance the system - ***

Many buildings are unable to reduce the domestic hot water temperature because of a few units which run cold. In such cases, increasing the recirculation pump to improve flow, and balancing risers to force flow out to more remote users can allow a general temperature reduction.

15. Insulation - ****

More than one half of buildings reported 50 percent or less insulated domestic hot water pipework. Tanks and all accessible pipes should receive 1 inch thick insulation, and risers should be insulated whenever they are replaced. Pipe riser shafts should be sealed at the top to restrict "chimney" air movement. Insulation reduces temperature loss around the system and normally allows the storage temperature to be further lowered.

16. Modify boiler controls - *
    (See method 4).

17. Improve boiler maintenance - ***
    (See method 2).

18. Install or make better use of peak electric demand controller - **
    Seventy-seven buildings report installation of controls which limit monthly peak electric demand. Such controls are rarely found to be used effectively, and operator training in their use is necessary. Sixty percent of projects have electric domestic water heating, and therefore are possible candidates for such a controller, depending upon building size and local electricity rate structures.

19. Install temperature setback control - *****
    The intent of this control is to reduce heat losses from the domestic hot water system during low use periods (primarily overnight). The simplest form is recirculation pump shutdown, but 2-stage temperature control may be applied instead if some users need hot water overnight.

. Ventilation Systems

20. Investigate ventilation air heat recovery potential - *
    Ventilation heat recovery is often cost effective in new building designs, but rarely so in retrofit applications. If the ventilation system has to run continuously, and the supply and exhaust fans are close together, and heating is provided by fuel oil or electricity, then heat recovery alternatives should be investigated.

21. Measure and reduce if possible bathroom exhaust airflows - ***
    Bathroom exhaust airflows are frequently found to be higher

than code requirements. Measurement and adjustment normally cost only a few hundred dollars, and show a very short payback primarily through savings in energy used to heat the air.

22. Measure and reduce if possible kitchen exhaust airflows - ***
(See method 21)

23. Measure and reduce if possible corridor pressurization airflows - ****
(See method 21)

24. Install timeclocks to reduce operating periods of exhaust fans - ***
More than 30 percent of buildings responding to the questionnaire reported shutting some or all ventilation fans down overnight. An almost equal number reported continuous fan operation. Reducing ventilation operating periods reduces the cost of heating and fanning the air, but should be approved by local governing bodies before implementation.

25. Install timeclocks to reduce operating periods of corridor pressurization fans - ***
(See method 24).

26. Improve ventilation maintenance - ****
Fans, fan belts, filters, motors, dampers, heat recovery equipment and ductwork must be well maintained before airflow measurements and changes are undertaken. Building operators should be trained to do much of this work themselves and to ensure that outside contractors do a good job.

27. Control recirculating systems - **
Many larger buildings contain recirculating type ventilation systems in basement, recreation and other areas. In addition to airflow changes (see method 21), reduced operating periods (see method 24) and improved maintenance (see method 26),

outside air intake to these systems should be measured and lowered if possible, thereby reducing heating costs.

28. Close smoke relief openings - **
Several buildings provide smoke relief openings in the tops of elevator shafts. These openings should be fitted with tight sealing, smoke activated dampers to prevent loss of heated air during non-emergency periods.

29. Close elevator penthouse and garbage chute vents in winter - ***
These other openings in the tops of some buildings should be restricted or even sealed in cold weather, again to prevent loss of heated air.

30. Install back draft prevention dampers on ventilation fans - ***
Dampers should be installed on fans which are shut down overnight to close during shutdown periods and thereby prevent loss of warm air rising up through the ventilation systems.

. Garage & Other Systems

31. Reduce garage temperature to 5°C - *
This will usually require replacement of existing thermostats, and may necessitate local insulation and pipe tracing.

32. Shutdown circulation pump in mild weather - *
If the outdoor temperature is above 5°C, the garage heating circuit should be shut down to prevent heat loss from the pipework.

33. Install carbon monoxide sensor to control exhaust fans - *
Underground garages require very high ventilation rates during peak usage periods, and the cost of heating that ventilation air can be high. Carbon monoxide sensors are specified in the National Building Code to safely restrict ventilation fan operating periods.

34. Discontinue heating the garage - *

Cost effectiveness of insulating and tracing pipework, insulating garage walls and ceilings and modifying the sprinkler system to allow garage heating to be discontinued should be investigated.

35. Reduce operating periods of ramp heater - **

Electric and glycol ramp heaters should be monitored for operating periods. If necessary, switches with indicator lights should be moved to more convenient location.

36. Provide or increase garage makeup airflow openings - ***

Adequate air makeup openings in underground garages must be provided and kept clear. Otherwise exhaust fans will tend to pull heated air out of the building.

37. Control operating periods of block heaters - *

Operation of block heaters and car warming heaters should ideally be controlled by outdoor temperature and according to time of day. Time cycling operating periods of groups of block heaters can also show significant savings particularly in regions where utilities bill winter demand year round.

38. Reduce incinerator burner operation - *

A time switch on the incinerator burner will automatically shut it down after a specified period.

. Lighting

39. Delamp corridors and stairwells - **

Required light levels are specified by provincial building codes or by local governing bodies. Building operators should be trained to measure current light levels and to delamp as much as possible. Delamping methods include removal of bulbs, removal of fixtures, use of "phantom" (no light output) tubes, and use of lower wattage lamps.

40. Replace incandescent with more efficienct fixtures - *****
Incandescent fixtures in corridors, stairwells, garages, lobbies and other common areas should be considered for conversion to more efficient, lower wattage, fluorescent fixtures. Incandescent outdoor lighting should be considered for conversion to more efficient, lower wattage low pressure sodium fixtures. Kitchen, bathroom and vestibule incandescent lighting within dwelling units should also be considered for conversion to fluorescent.

41. Reduce lighting operation in daylit areas - ****
Outside lighting, and interior lighting in stairwells, lobbies and other areas which receive daylight, should ideally be controlled by timeclocks with photocell overrides.

Discussion

One or more of the energy management methods outlined above will apply to everyone of the estimated 1650 eligible public housing projects. There will also be other opportunities which are specific to particular buildings, and which frequently result from unusual and undetected equipment malfunctions. Just as often it has been found that methods do not produce anticipated savings in some buildings because the building operator has already implemented changes of his own. The importance of an effective audit procedure to ensure that the right things are done in the right buildings is self-evident. This procedure must take into account the fact that the majority of eligible projects contain 59 dwelling units or less and therefore cannot support the expense of detailed studies by outside professionals.

Long experience of building operators with their buildings, identified in Section 4, is complemented by a generally high calibre of operating personnel interviewed during the site visits. Many of the energy management methods outlined above require their active involvement, and it is anticipated that building operator and manager training programs will prove to be valuable energy management investments.

6. ENERGY ANALYSIS

Scope and Method

Detailed energy analysis of eight buildings was undertaken using the SUMAC energy audit program and an energy target setting procedure developed by the Ontario Ministry of Municipal Affairs and Housing. While it is recognized that the sample size is too small to be statistically meaningful, the purpose of this part of the study was threefold:

- to provide detailed energy data on a small, but representative sample of public housing projects for comparison with equivalent data obtained previously for well over one hundred comparable buildings which came mostly from the private sector
- to provide a model for estimating potential energy savings throughout the eligible public housing portfolio, and to help derive initial input for that model
- to demonstrate the capabilities of detailed energy analysis as a simple method of auditing buildings for purposes of energy management.

Individual Energy Audits, Energy Targets and simple action checklists are attached in Appendix E.

Selection of Buildings

Buildings were selected according to types of energy used (compatible with generic building groups developed in Section 4) and availability of adequate energy use records. Table 6.1 provides a list of the buildings together with sizes, locations and types of energy used.

Seven of these buildings were included in the site surveys. The eighth, 124 Elmview Avenue in Welland, Ontario, was added later to supplement data on all-electric buildings.

Building	Location	Types of Energy Used	No. of Dwelling Units
Sir J. Thompson Manor	Halifax	Fuel heated*, low-rise	168
73 Augusta Square	Toronto	Fuel heated*, high-rise	143
1920 Paris Street	Sudbury	Fuel heated*, high-rise	101
Canora Gardens	Edmonton	Fuel heated*, high-rise	98
191 Main Street	Hamilton	Hybrid**, high-rise	265
720 Bruce Street	Sudbury	Hybrid**, high-rise	251
66 King Street West	Mississauga	All electric, high-rise	121
124 Elmview Ave.	Welland	All electric, low-rise	56

* Including domestic hot water and corridor pressurization ventilation

** Electric space heating, fuel heated domestic hot water and corridor pressurization ventilation

TABLE 6.1 BUILDINGS SELECTED FOR DETAILED ENERGY ANALYSIS

The SUMAC Energy Audit

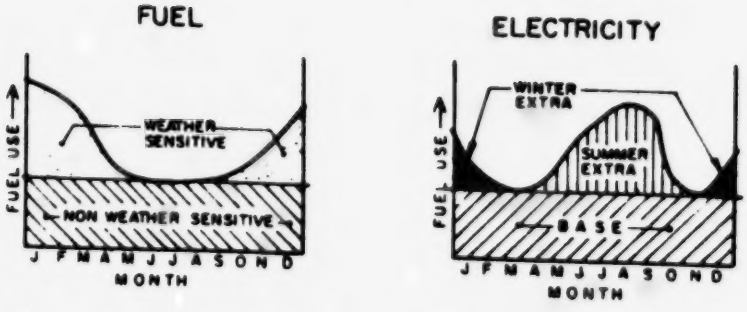
SUMAC is the acronym of a computerized energy analysis system developed by Engineering Interface in Toronto. It comprises a number of elements, only one of which, the Energy Audit, was used for this part of the study.

The SUMAC energy audit is a detailed computerized analysis of historical energy use as recorded on a building's utility bills. Its purpose is to obtain as much information as possible from those readily available records before any visit to the building. The analysis involves three major elements as follows:

Energy Breakdowns

Energy use comparisons between buildings with similar physical characteristics, use and occupancy are used widely to help identify those likely to show the greatest savings potential. The purpose of energy breakdowns is to focus attention on building systems which are likely to be responsible for differences in energy use. Shown below is a simplified illustration of the patterns which result from normalizing energy use data from the bills for a building to a common billing period, dividing them by the building area, and graphing them for a calendar year. Breakdowns are obtained by drawing horizontal lines through points where seasonal systems are not in use. Non-seasonal or base energy use for building systems can be estimated by integrating below the horizontal line, and energy use for seasonal systems can be derived by integration above the horizontal line. In the case of fuel, this non-seasonal base

SUMAC ENERGY BREAKDOWNS



line can often be approximated to consumption recorded in summer months. With electricity, the non-seasonal base line is often established in spring and fall when both electric heating and cooling are off. Larger buildings are usually billed for maximum monthly electrical demand, as well as for consumption, allowing similar seasonal/non-seasonal breakdowns to be developed for both electrical demand and consumption. From this energy breakdown analysis, the components of energy use shown in Table 6.2 may be derived:

Table 6.2 Energy Use Components

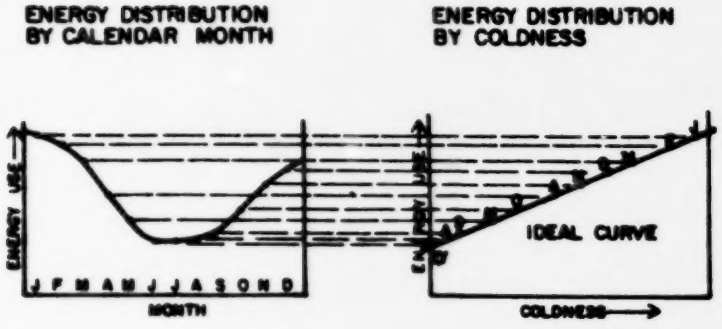
Component	Typical Associated Systems
Fuel - Non-Seasonal (Non-weather Sensitive)	. Domestic hot water . Pool heaters . Laundries . Incinerators
Fuel - Seasonal (Weather Sensitive)	. Space heating . Ventilation air heating . Infiltration . Entrance heating
Electricity - Non-Seasonal (Base)	. Lighting . Equipment . Appliances . Fans . Elevators
Electricity - Seasonal (Winter Extra)	. Electric heat . Longer hours of fans and/or lights
Electricity - Seasonal (Summer Extra)	. Air conditioning . Summer domestic water heating

The simplicity of the concept of energy breakdowns contrasts with the complexity of achieving them in practice. Estimated bills are commonplace, and can wreak havoc with the simplified pattterns shown. Non-seasonal base lines are rarely linear. Individual fuel oil deliveries need not bear much relationship to the amount consumed since the previous delivery unlesss storage is always completely filled. In buildings with high balance point temperatures, heating and cooling seasons can overlap to entirely obscure the non-seasonal base line position. As a result of problems such as these, a significant percentage of energy breakdown analyses require involvement of an energy analyst. A simple building information questionnaire is provided with each audit to guide the analyst and to help apply previous experience with other similar buildings to produce reliable breakdowns.

Weather Normalization

Breakdowns of energy use allow comparison between buildings irrespective of their geographic location, except for energy components which are weather dependent. SUMAC is at present programmed to handle heating weather differences, and does so through development of a method which has been in use by larger fuel utilities and others for many years. The illustration below again shows the monthly energy use pattern for a calendar year, and develops that pattern into the equivalent distribution according to how cold the weather was during each month. Resultant curves have been shown to be linear for buildings which are operated consistently throughout the heating season. Correlation coefficients above 0.99 are not unusual when linear regression is applied to the seven winter months.

SUMAC PATTERN ANALYSIS



The traditional measure of coldness is degree days. There has been a good deal of debate about appropriate balance temperatures from

which to measure degree days for a particular building. The subject is a complex one, and cannot be fully covered here. SUMAC uses a curve fitting method based on grouping consecutive monthly points to avoid problems of estimated bills. Under suitable circumstances, the best fit obtained from testing at each integer balance temperature from 18°C. to 5°C. can be adopted as the building's effective balance temperature. This method works well with climates having several months containing days with average temperatures ranging from 10°C. to 20°C. such as Vancouver and Washington. It is not useful in climates which change sharply from heating to cooling season such as Toronto, Edmonton and Montreal. The alternative balance point estimation method used by SUMAC is based on the relationship between the intercept of the curve with the y-axis and the location of the summer months. A similar method has been outlined by the Chartered Institute of Building Services in the United Kingdom. If neither of these methods proves satisfactory, then the analyst may impose a balance temperature based on previous results from similar buildings.

Once the effective balance temperature is established, then winter fuel consumption may be expressed as a simple polynomial:

$$F = A.\ x + B.\ d$$

where F = fuel consumption for the winter period

A = the slope of the curve

x = the number of degree days for the winter period at the building's balance temperature in the buildings's location

B = the intercept of the curve with the y-axis (zero degree days)

d = the number of days in the winter period.

Once factors A and B are developed for a particular building, then they may be compared with equivalent data for any other building, irrespective of geographic location.

Pattern Recognition

Having identified the ideal linear curve exhibited by consistently operated buildings, it should be added that only a minority of buildings are operated in this way and display this linearity. During early stages of development, non-linearity was not understood and was particularly irritating. As the number of analyses moved from tens to hundreds and then to thousands, however, some order began to emerge and patterns became recognizable to the energy analyst during the review stages of the analysis. Some of those patterns were no more exciting than estimated bills followed by equal and opposite compensations. Many, however, were more interesting. An apartment building which overheats in spring and fall displays a bowed curve quite unlike the linearity of the well controlled building. Poor boiler sequencing and control can exhibit different curves at different times of year. Manual ventilation control can show hysteresis patterns year after year.

A worked example of the Energy Audit procedure for 191 Main Street/200 Jackson Street in Hamilton is attached in Appendix E.

Energy Target Calculation

The energy audit provides a detailed statement of a building's energy use. The equal partner in a meaningful analysis is the energy target, which is the lowest economically attainable energy use level for the building, recognizing its physical characteristics, use and occupancy. Means of establishing energy targets range from costly and time consuming computer simulation through to simple adoption of the low decile energy use level from a large number of buildings of a particular type. For the purpose of this study, the longhand method contained in the Do-It-Yourself Energy Audit package developed by the Ontario Ministry of Municipal Affairs and Housing was used. The method considers wall, window and roof areas, systems present in the building and types of building occupants. It uses a basic target for each energy system, which is drawn from a large database of apartment building energy

use, and modifies that target according to the particular situation in the building. A worked example of the calculation method for 1920 Paris Street in Sudbury is also attached in Appendix E.

Findings

Two findings from this part of the study are presented:

- Energy use by the eight buildings compared with SUMAC database averages. - Table 6.3
- Potential energy savings for the eight buildings according to calculated energy targets. - Table 6.4

Note that the SUMAC metric of summer extra electricity use, which generally represents air conditioning, and is therefore virtually absent from public housing projects, is not included in these tables.

Analysis results shown in Table 6.2 show that energy use levels for the eight buildings are almost all substantially below both SUMAC database industry averages and the Ontario Housing Corporation averages developed in Section 4. It is therefore concluded that these buildings are unlikely to be representative of the public housing stock, leaving the Ontario Housing Corporation averages as the most reliable basis for analysis.

Despite relatively low current energy use, all eight buildings show apparent potential savings, with the best potential seen in fuel heated buildings.

	ENERGY USE MJ/SQ.M./YR.							AVERAGE ELEC. DEMAND WATTS/SQ.M.		
	FUEL			ELECTRICITY						
	Non-Weather Sensitive	Weather Sensitive	Total	Base	Winter Extra	Total	Grand Total	Base	Winter Extra	Total
All Electric Buildings										
66 King Street	-	-	-	339	300	639	639	22.6	10.2	32.8
124 Elmview	-	-	-	331	298	629	629	21.7	11.1	32.8
Industry Average	-	-	-	487	313	800	800	29.1	13.7	42.8
OHC Average							734			
Fuel-Heated Buildings										
73 Augusta	474	833	1307	230	17	247	1554	11.9	1.1	13.0
Canora Gdns.	275	346	621	261	32	293	914	17.4	1.8	19.2
1920 Paris	191	505	696	188	14	202	898	10.1	2.6	12.7
Sir J. Thompson	173	374	547	196	29	225	772	12.2	1.5	13.7
Average	278	514	792	218	22	240	1032	12.9	1.7	14.6
Industry Average	356	732	1088	216	27	243	1333	12.7	1.8	14.5
OHC Average							1708			
Hybrid-Heated Buildings										
191 Main	246	225	471	197	259	456	927	13.2	10.3	23.6
720 Bruce	233	155	388	209	210	419	807	13.7	9.9	23.6
Industry Average	214	146	360	300	265	565	925	19.7	12.8	32.5
OHC Average							1100			

NOTES: Weather dependent energy components normalized to a Toronto standard weather year.
: Hybrid heating is electric space heat; fuel domestic hot water and corridor heat.
: Ontario Housing Corporation averages come from Section 4.

TABLE 6.3 CURRENT ENERGY USE FOR EIGHT PUBLIC HOUSING PROJECTS COMPARED WITH INDUSTRY AVERAGES

	Fuel			Electricity		
	Non-Weather Sensitive %	Weather Sensitive %	Total %	Winter Base %	Extra %	Total %
All Electric						
66 King Street W.	-	-	-	16.8	11.3	13.9
124 Elmview	-	-	-	13.0	10.7	12.1
Average				14.9	11.0	13.0
Fuel Heated						
73 Augusta Square	28.2	24.4	26.3	24.0	56.5	26.3
Canora Gdns.	40.1	3.0	21.6	25.9	57.8	30.7
1920 Paris St.	15.8	27.9	21.9	7.2	45.9	10.0
Sir J. Thompson Manor	5.1	4.3	4.7	11.4	73.0	19.3
Average	22.3	14.9	18.6	17.1	58.3	21.6
Hybrid						
191 Main St.	33.8	51.8	42.4	0.0	0.0	0.0
720 Bruce St.	16.5	64.8	35.9	12.8	0.0	6.7
Average	25.2	58.3	39.2	6.4	0.0	3.4

Note: These percentages are drawn from the building energy audit for each location (See Appendix E).

TABLE 6.4 PERCENTAGE ENERGY SAVINGS POTENTIAL FOR EIGHT PUBLIC HOUSING PROJECTS

7. ESTIMATION OF POTENTIAL SAVINGS

Scope and Method

This section of the report uses the data developed in previous sections to estimate total potential energy cost savings for the entire public housing portfolio which qualifies under the terms of reference of the study. The model used may be summarized as follows for each generic building group:

Estimated No.of Dwelling Units	x	Estimated Average Building Area per Dwelling Unit	x	Estimated Current Average Energy Use per Square Metre	x
I		II		III	

Estimated Average Percentage Energy Savings Potential	x	Blended National Average Unit Energy Costs	=	Potential Savings
IV		V		

Estimated Number of Dwelling Units

This information is taken from Sections 3 and 4 of this report. There were 154,000 possible eligible dwelling units identified from the C.M.H.C. file search, but there was some question about eligibility of row housing units. The total was therefore reduced to 145,000 units. Breakdown of these units among the six generic building groups was based on analysis of the returned questionnaires, as follows:

Building Type		Percent of Units	No. of Units
All-Electric	-Medium- & High-Rise	22	32,000
	-Low-rise	24	34,600
Fuel Heated	-Medium- & High-Rise	30	42,600
	-Low-rise	9	13,700
Hybrid Heat	-Medium & High-Rise	9	13,500
	-Low-rise	6	8,600
		100	145,000

Estimated Average Building Area per Dwelling Unit

Building areas were generally not included in responses to the questionnaire, while specific numbers and types of dwelling units in the buildings were not asked for. Gross heated building areas divided by numbers of units for several public and private sector family and seniors' buildings which had been analysed previously were used to produce the averages shown below. These averages were blended according to the percentages of adult, family and mixed dwelling units in the database obtained from the questionnaires. (Section 4)

Occupancy Type	Percentage of Dwelling Units in Database	Estimated Average Gross Building Area per Unit Sq.m.
Family	15.3	110
Senior Citizen	80.0	65
Mixed	4.7	80
Blended Average	100.0	72

Estimated Current Average Energy Use per Square Metre

Too few buildings were analysed in Section 6 for the resultant energy breakdowns to be useful for this model. Energy use averages, without breakdowns, were therefore taken from the data provided by Ontario Housing Corporation and discussed in Section 4. These averages are:

Building Type	Current Ontario Based Average Energy Use MJ/sq.m./yr.
All Electric	734
Fuel Heated	1,708
Hybrid Heated	1,100

Recognizing that these averages are based on the Ontario climate, it was considered necessary to adjust them to weighted national average weather conditions. Table 7.1 develops weighted national degree day factors, using major cities from the five regions of Canada. The simple degree day factors shown are the ratios of local degree days to Toronto degree days. Weighted degree day factors are obtained by multiplying the simple factors by the percentages of dwelling units in the five regions, and this procedure is repeated for the three building categories (all-electric, fuel-heated, hybrid heated). Stage 2 in Table 7.1 shows estimated percentages of energy averages which are weather dependent, and applies national weighted degree day factors to produce energy averages more representative of the national building stock. These averages are:

Building Type	Current National Based Average Energy Use MJ/sq.m./yr.
All-Electric	750
Fuel-Heated	1,765
Hybrid-Heated	1,105

Estimated Average Percentage Energy Savings Potential

Section 6 showed a calculation of potential energy savings for the eight buildings that were subjected to the audit. These buildings were chosen to include examples of several types based on number of stories and heating systems. Comparison of the recent performance of these eight buildings with the Ontario average shows that they used substantially less energy i.e. they are not representative in terms of their energy consumption. The question arises as to which figure to use as a basis for savings - the sample of eight, or the Ontario average. The original intention of using the sample was chosen, and the potential savings were calculated and further reduced by a factor that, on the judgement of the consultant, allowed for their achievement in practice. The final savings potentials are shown below:

Building Type	Estimated Average Energy Savings Potential Percent Fuel	Electricity
All-Electric	-	10 (13)
Fuel-Heated	15 (18.6)	15 (21.6)
Hybrid-Heated	30 (39.2)	10 (3.4)

Figures in parentheses are averages from Table 6.4

Blended National Average Unit Energy Costs

In order to translate potential energy savings into potential dollar savings, a blended national average unit energy cost was developed as shown below. The procedure mutliplies typical local incremental unit energy costs for the five regions by the percentage of dwelling units in the database from Section 4 for those regions to obtain the blended national average.

Region	Percentage of Dwelling Units in Database	Typical Incremental Utility Costs (1982) Fuel $/GJ	Electricity* ¢/kWhr
Atlantic	2	6.85 (fuel oil)	4.6
Quebec	15	5.30	3.0
Ontario	61	4.25	3.3
Prairies	17	2.25	3.4
British Columbia	5	3.45	3.1
Blended National Average	100	4.10	3.3 ($8.65/GJ)

*Blended consumption and demand cost.

Calculation of Potential Energy and Cost Savings

Table 7.2 uses all of these elements to develop the estimated current annual energy use and potential annual energy cost savings for the entire Canadian public housing portfolio which qualifies for this study.

Discussion

It will be apparent that there is potential error in each of the estimates used in the model. Relatively low response rates to the questionnaire from Eastern Canada may also introduce some bias to these findings (see Table 4.1). In total, the results shown in Table 7.2 are felt to be realistic and somewhat conservative. It is recommended, however, that improvement of the model's reliability should be an ongoing part of the evolving public housing energy upgrading program. The following checklist is arranged in order of priority, according to reliability of figures used in Table 7.2 and sensitivity of results to accuracy of each element.

- Element IV - Average Percentage Energy Savings Potential
  Analyse more buildings from different regions and from all six generic types to improve the estimate of percentage potential savings. Monitor results of retrofit.

- Element III - Current Average Energy Use Per Sq. Metre
  Analyse historic energy use from more buildings from different regions and from all six generic type to develop a more reliable, broken down profile of current energy use. This profile will indicate which energy systems are likely to yield the greatest savings.

- Element II - Average Building Area per Dwelling Unit
  As more buildings are analysed, heated areas and dwelling unit counts will be obtained to allow this figure to be refined.

- Element I - Number of Dwelling Units
  Provincial studies will be completed shortly, at which time these figures will be finalised.

- Element V - Blended National Average Unit Energy Costs
  These figures should be indexed periodically to reflect cost escalation.

TABLE 7.1 DERIVATION OF NATIONAL AVERAGE ENERGY USE PER SQ. M.

STAGE 1

Calculate weighted degree-day factors by considering first the number of degree days in each region relative to Toronto, and then the percentage distribution of each dwelling unit category among those regions.

Region	Centre	Centigrade Degree Days	Simple D.D. Factor (vs Toronto)	Distribution All-Electric Units %	Weighted Deg.Days Factor	Distribution Fuel-Heated Units %	Weighted Deg.Days Factor	Distribution Hybrid-Heated Units %	Weighted Deg.Days Factor
Maritime	Halifax	4,123	1.01	1.3	0.013	4.1	0.041	2.6	0.026
Quebec	Montreal	4,471	1.10	23.4	0.250	1.5	0.016	18.6	0.204
Ontario	Toronto	4,082	1.00	64.6	0.646	48.3	0.483	59.0	0.59
Prairies	Calgary	5,345	1.31	8.1	0.106	34.5	0.452	11.5	0.151
West.	Vancouver	3,007	0.74	2.6	0.019	11.6	0.085	8.3	0.061
National Weighted Degree Day Factors					1.04		1.08		1.03

National weighted degree day factors represent the national average coldness relative to Toronto weighted according to the public housing population in each major Canadian region.

STAGE 1

Apply weighted degree day factors to Ontario weather based average energy use for the three building categories by first estimating the percentage of energy use which is weather dependent.

Building Type	Average Ontario Based Energy Use MJ/sq.m./yr.	Estimated Weather Dependent Percentage %	National Weighted Degree Day Factor	Average National Energy Use MJ/sq.m./yr.
All-Electric	734	50	1.04	750
Fuel-Heated .Fuel				
.Elec.	1,708	40	1.08	1,765
Hybrid Heated .Fuel				
.Elec	1,100	15	1.03	1,105

TABLE 7.2 ESTIMATED CURRENT ANNUAL ENERGY USE AND POTENTIAL ENERGY SAVINGS FOR THE CANADIAN PUBLIC HOUSING STOCK WHICH QUALIFIES FOR THIS STUDY

Building Type	Estimated Total Units	Estimated Current Energy Use TJ/year		Estimated Cost Million$/yr	Estimated Potential Savings TJ/yr.		Estimated Potential Cost Savings Million$/yr.	$/Unit
		Electricity	Fuel		Electricity	Fuel		
All-Electric								
Medium & High-Rise	32,000	1,728	-	15.0	173		1.5	47
Low-Rise	34,600	1,868	-	16.2	187		1.6	
Fuel-Heated								
Medium & High-Rise	42,600	899	4,514	26.3	135	677	4.0	94
Low-Rise	13,700	289	1,452	8.5	43	218	1.3	
Hybrid-Heated*								
Medium & High-Rise	13,500	714	360	7.7	71	108	1.1	81
Low-Rise	8,600	455	229	4.9	45	69	0.7	
Totals	145,000	5,953	6,555	78.6	654	1,072	10.2	70

*Hybrid heating is electric space heating with gas-heated domestic hot water and corridor heating.

8. CONCLUSIONS

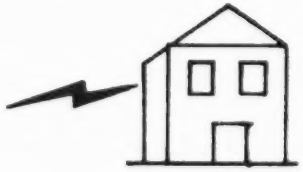
- There are an estimated 1,650 public housing projects, containing 145,000 dwelling units, which qualify for this project.
- Current energy use is estimated at 12,500 TJ/yr., costing $78.6 million/year at 1982 rates.
- Potential energy cost savings, without major upgrading of the building envelope, were estimated to be $10.2 million/year. Further energy analysis of projects is recommended to improve the reliability of this estimate.
- The technology to achieve those savings exists and has been proven in Canada and overseas. It falls into two major categories:
  - modifying building systems
  - improving operation of building systems
- A comprehensive energy upgrading program presents a considerable task, beyond anything attempted in any other country.
- Building managers and operators generally have longer experience with the same building than their counterparts in the private sector.
- In order to achieve potential energy savings, the following will be necessary at a local level
  - knowledge of how to identify and implement energy management action which applies
  - accountability for good energy performance
  - means of judging the effectiveness of action taken.
- There is little, if any, public housing within the scope of this study where tenants have any incentive to conserve. Tenants are directly responsible for about 20 percent of total energy use, or $15 million/year. Based on previous study by Ontario Hydro and others, up to one third of this amount might be saved through tenants paying for their own energy, which would increase potential savings estimated in this study by fifty percent.

- Each province and its housing authorities have their own operating systems which must be taken into account in development of an energy management program. The questionnaire response rate, however, suggests that in most provinces communication within individual housing corporations is already very good.
- A well documented, successful energy management program in public housing may be expected to stimulate corresponding action in the private sector.
- Profiles of the six generic building groups and of energy management actions likely to be appropriate in each appear in Figures 8.1-8.6. Refer to Section 5 - "Energy Management Methods Identified" - for a more complete description of these actions.

FIGURE 8.1 - SUMMARY AND ACTION CHECKLIST FOR ALL-ELECTRIC LOW-RISE BUILDINGS

CONCLUSIONS - TECHNOLOGY

1. ALL-ELECTRIC BUILDINGS - LOW RISE



	Buildings		Suites	
	No.	Percent	No.	Percent
MARITIMES	7	1.7	210	1.4
QUEBEC	93	23.0	3,270	21.0
ONTARIO	264	65.5	10,285	66.1
PRAIRIES	25	6.2	1,140	7.3
WEST	14	3.6	625	4.2
TOTAL	403	100	15,530	100

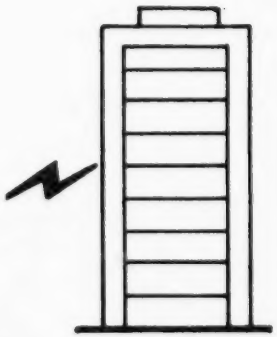
Above figures represent number of buildings and number of suites in database.

	ACTION	TYPICAL COST $/SUITE	TYPICAL PAYBACK YEARS
1.	Install, upgrade electrical demand controller	50	0.1 - 5.0
2.	Install electric heat storage	200	3.0 - Never
3.	Measure, adjust central ventilation airflows	15	0.1 - 5.0
4.	Reduce ventilation fan operation	10	0.1 - 0.5
5.	Control snowmelting, block heaters	10	0.3 - 2.0
6.	Reduce domestic hot water temperatures, quantities	20	0.1 - Never
7.	Reduce domestic hot water transmission losses	25	1.0 - 2.5
8.	Delamp, reduce wattage, convert lighting fixtures	50	0.8 - 5.0
9.	Local insulation, storm windows, weatherstripping	50	3.0 - 10.0
10.	Action specific to the individual building	N/A	N/A

FIGURE 8.2 - SUMMARY AND ACTION CHECKLIST FOR ALL-ELECTRIC HIGH-RISE BUILDINGS

CONCLUSIONS - TECHNOLOGY

2. ALL-ELECTRIC BUILDINGS - MID/HIGH-RISE



	Buildings		Suites	
	No.	Percent	No.	Percent
MARITIMES	0	0	0	0
QUEBEC	34	24.3	2,805	19.5
ONTARIO	87	62.1	9,530	66.3
PRAIRIES	19	13.6	2,040	14.2
WEST	0	0	0	0
TOTAL	140	100	14,375	100

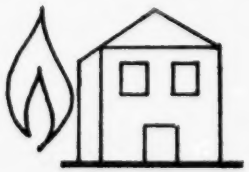
Above figures represent number of buildings and number of suites in database.

	ACTION	TYPICAL COST $/SUITE	TYPICAL PAYBACK YEARS
1.	Install, upgrade electrical demand controller	50	0.1 - 5.0
2.	Install electric heat storage	200	3.0 - Never
3.	Measure, adjust central ventilation airflows	15	0.1 - 5.0
4.	Reduce ventilation fan operation	10	0.1 - 0.5
5.	Control snowmelting, block heaters	10	0.3 - 2.0
6.	Reduce domestic hot water temperatures, quantities	20	0.1 - Never
7.	Reduce domestic hot water transmission losses	25	1.0 - 2.5
8.	Delamp, reduce wattage, convert lighting fixtures	50	0.8 - 5.0
9.	Local insulation, storm windows, weatherstripping and vent sealing	50	3.0 - 10.0
10.	Action specific to the individual building	N/A	N/A

FIGURE 8.3 - SUMMARY AND ACTION CHECKLIST FOR FUEL-HEATED LOW-RISE BUILDINGS

CONCLUSIONS - TECHNOLOGY

3. FUEL-HEATED BUILDINGS - LOW RISE



	Buildings		Suites	
	No.	Percent	No.	Percent
MARITIMES	10	9.4	765	12.5
QUEBEC	0	0	0	0
ONTARIO	31	29.2	1,770	28.8
PRAIRIES	45	42.5	1,780	29.0
WEST	20	18.9	1,825	29.7
TOTAL	106	100	6,140	100

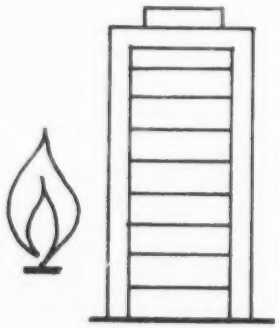
Above figures represent number of buildings and number of suites in database.

	ACTION	TYPICAL COST $/SUITE	TYPICAL PAYBACK YEARS
1.	Service repair, upgrade boilers and furnaces	60	0.2 - 3.0
2.	Change fuel	100	1.5 - 5.0
3.	Add, upgrade central heating control, service heating system	15	0.2 - 3.0
4.	Reduce ventilation fan operation	10	0.1 - 0.5
5.	Measure, adjust central ventilation airflows	30	0.1 - 5.0
6.	Control snowmelting, block heaters	10	0.3 - 2.0
7.	Reduce domestic hot water temperatures, quantities	20	0.1 - Never
8.	Reduce domestic hot water transmission losses	25	1.0 - 2.5
9.	Delamp, reduce wattage, convert lighting fixtures	50	0.8 - 5.0
10.	Local insulation, storm windows, weatherstripping and vent sealing	50	3.0 - 10.0
11.	Control garbage incinerator burner	5	0.1 - 2.0
12.	Use electric heat off peak billing demand	50	2.0 - 10.0
13.	Action specific to the individual building	N/A	N/A

FIGURE 8.4 - SUMMARY AND ACTION CHECKLIST FOR FUEL-HEATED HIGH-RISE BUILDINGS

CONCLUSIONS - TECHNOLOGY

4. FUEL-HEATED BUILDINGS - MID/HIGH-RISE



	Buildings		Suites	
	No.	Percent	No.	Percent
MARITIMES	1	0.6	175	.9
QUEBEC	4	2.5	140	.7
ONTARIO	98	60.9	12,475	65.2
PRAIRIES	47	29.2	4,790	25.0
WEST	11	6.8	1,570	8.2
TOTAL	161	100	19,150	100

Above figures represent number of buildings and number of suites in database.

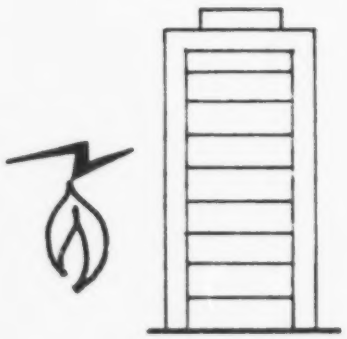
	ACTION	TYPICAL COST $/SUITE	TYPICAL PAYBACK YEARS
1.	Service repair, upgrade boilers and furnaces	60	0.2 - 3.0
2.	Change fuel	100	1.5 - 5.0
3.	Add, upgrade central heating control, service heating system		0.2 - 3.0
4.	Reduce ventilation fan operation	10	0.1 - 0.5
5.	Measure, adjust central ventilation airflows	30	0.1 - 5.0
6.	Control snowmelting, block heaters	10	0.3 - 2.0
7.	Reduce domestic hot water temperatures, quantities	20	0.1 - Never
8.	Reduce domestic hot water transmission losses	25	1.0 - 2.5
9.	Delamp, reduce wattage, convert lighting fixtures	50	0.8 - 5.0
10.	Local insulation, storm windows, weatherstripping and vent sealing	50	3.0 - 10.0
11.	Control garbage incinerator burner	5	0.1 - 2.0
12.	Use electric heat off peak billing demand	50	2.0 - 10.0
13.	Action specific to the individual building	N/A	N/A

FIGURE 86 - SUMMARY AND ACTION CHECKLIST FOR HYBRID HIGH RISE BUILDINGS

CONCLUSIONS - TECHNOLOGY

ELECTRIC SPACE HEATING, FUEL HEAT FOR DOMESTIC HOT WATER AND/OR CORRIDOR VENTILATION

HIGH-RISE



	Buildings		Suites	
	No.	Percent	No.	Percent
MARITIMES	1	1.4	50	0.9
QUEBEC	14	20.6	780	12.9
ONTARIO	43	63.3	4,675	77.3
PRAIRIES	6	8.8	260	4.3
WEST	4	5.9	280	4.6
TOTAL	68	100	6,045	100

Above figures represent number of buildings and number of suites in database.

	ACTION	TYPICAL COST $/SUITE	TYPICAL PAYBACK YEARS
1.	Service, Repair, upgrade boilers and furnaces	15	0.2 - 2.0
2.	Reduce Ventilation fan operation	10	0.1 - 0.5
3.	Measure, adjust central ventilation airflows	15	0.1 - 5.0
4.	Control snowmelting, block heaters	10	0.3 - 2.0
5.	Reduce Domestic hot water temperatures, quantities	20	0.1 - Never
6.	Reduce domestic hot water transmission losses	25	1.0 - 2.5
7.	Delamp, reduce wattage, convert lighting fixtures	90	0.8 - 5.0
8.	Local insulation, storm windows, weather stripping and vent sealing	50	3.0 - 10.0
9.	Use electric heat off peak billing demand	50	1.0 - 5.0
10.	Action specific to the individual building	N/A	N/A

FIGURE 85 - SUMMARY AND ACTION CHECKLIST FOR HYBRID LOW-RISE BUILDINGS

CONCLUSIONS - TECHNOLOGY

5 ELECTRIC SPACE HEATING, FUEL HEAT FOR DOMESTIC HOT WATER AND/OR CORRIDOR VENTILATION LOW-RISE

	Buildings		Suites	
	No.	Percent	No.	Percent
MARITIMES	3	3.4	190	4.9
QUEBEC	15	17.1	550	14.2
ONTARIO	49	55.7	2,185	56.2
PRAIRIES	12	13.6	520	13.4
WEST	9	10.2	440	11.3
TOTAL	88	100	3,885	100

Above figures represent number of buildings and number of suites in data base.

	ACTION	TYPICAL COST $/SUITE	TYPICAL PAYBACK YEARS
1.	Service, Repair, upgrade boilers and furnaces	15	0.2 - 2.0
2.	Reduce Ventilation fan operation	10	0.1 - 0.5
3.	Measure, adjust central ventilation airflows	15	0.1 - 5.0
4.	Control snowmelting, block heaters	10	0.3 - 2.0
5.	Reduce Domestic hot water temperatures, quantities	20	0.1 - Never
6.	Reduce domestic hot water transmission losses	25	1.0 - 2.5
7.	Delamp, reduce wattage, convert lighting fixtures	90	0.8 - 5.0
8.	Local insulation, storm windows, weather stripping and vent sealing	50	3.0 - 10.0
9.	Use electric heat off peak billing demand	50	1.0 - 5.0
10.	Action specific to the individual building	N/A	N/A

9. RECOMMENDATIONS

An Energy Management Model for Public Housing in Canada

In order to promote effective and consistent management of the $78,600,000 energy resources currently used in the public housing sector, it is recommended a total energy management program incorporating an energy information system be adopted. The system, based on proven state-of-the-art technology, will be operated at the provincial level. A total investment of up to $35 million spread over five years will be required. Energy conservation savings potential identified in this report is $10.2 million/yr.

Before adopting the complete system a pilot project will be undertaken as stage two of this study. This will involve between 50 and 100 buildings in three or four provinces and will cost between $158,000 and $220,000.

The energy management model proposed for public housing in Canada is shown in Figure 9.1. It recognizes the need for flexibility in the Action stage to allow local housing authorities to proceed at their own pace, to make use of locally available resources in different parts of Canada, and to be compatible with existing provincial and territorial policies and programs. It recommends consistency of energy Auditing and Monitoring to facilitate allocation of resources for the best return on investment. It incorporates computerized information reporting capabilities to allow the anticipated large volume of information generated by widespread action to be captured and analyzed for helping with future policy and planning.

The Audit identifies potential savings together with actions and costs necessary to achieve those savings. Action is the implementation stage, and Monitoring of ongoing energy use serves to track results of that action.

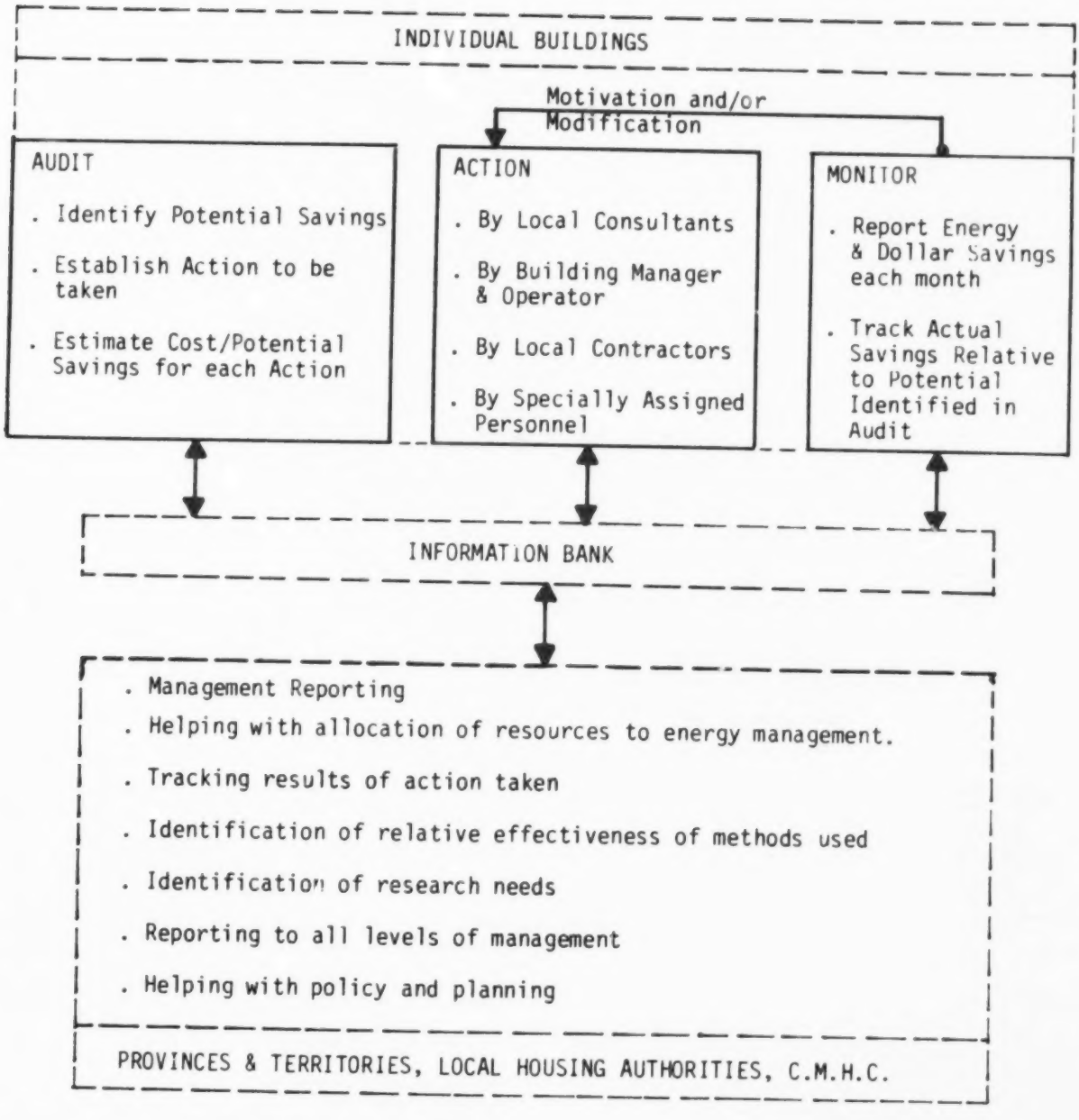

INDIVIDUAL BUILDINGS
Motivation and/or Modification
AUDIT
. Identify Potential Savings
. Establish Action to be taken
. Estimate Cost/Potential Savings for each Action
ACTION
. By Local Consultants
. By Building Manager & Operator
. By Local Contractors
. By Specially Assigned Personnel
MONITOR
. Report Energy & Dollar Savings each month
. Track Actual Savings Relative to Potential Identified in Audit
INFORMATION BANK
. Management Reporting
. Helping with allocation of resources to energy management.
. Tracking results of action taken
. Identification of relative effectiveness of methods used
. Identification of research needs
. Reporting to all levels of management
. Helping with policy and planning
PROVINCES & TERRITORIES, LOCAL HOUSING AUTHORITIES, C.M.H.C.

FIGURE 9.1 **An Energy Management Model For Public Housing In Canada**

The Audit

The requirements of the Audit are as follows:

- to identify potential savings in each project
- to establish actions necessary to achieve those savings
- to estimate cost and potential savings for each action.

Consistency in the Audit is recommended for all projects so that provinces and local housing authorities can see clearly where their best opportunities lie, and so that proven, effective energy management measures can be made known to all projects across Canada. It is therefore proposed that an energy audit procedure be conducted for each project being considered for energy management action to provide:

- analysis of actual energy use for the past year
- comparison with energy use data for other similar buildings
- budget or target energy use for the building, recognizing its occupancy and its unalterable physical characteristics
- identification of energy systems requiring action or investigation in order to achieve target energy use
- a statement of energy management actions likely to be appropriate, together with likely costs and potential savings associated with each action.

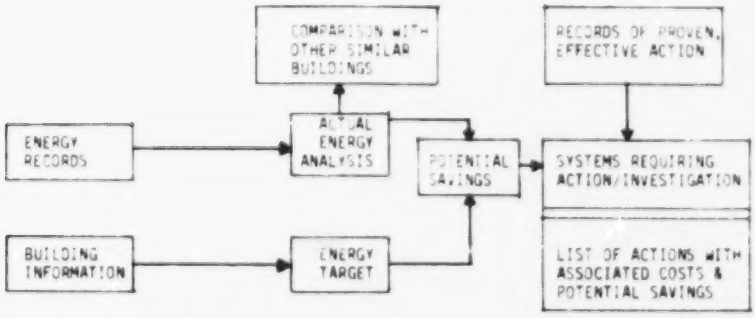


FIGURE 9.2 **Energy Audit Procedure**

This procedure is shown diagrammatically in Figure 9.2. The energy target represents the energy requirement of each project with ideal energy system operation. The difference between actual and target energy use defines potential savings. The potential savings figure provides accountability for whoever undertakes the action stage of the program, since they will be responsible for achieving those savings. It also identifies relative effectiveness of different implementation methods by tracking how quickly they reach target energy use. Finally, by gaining this preliminary view of potential savings and associated costs for each of their projects, housing authorities and provinces are helped with short and long term planning and with allocation of resources for the best return on investment. It should be noted that this energy audit fills most of the requirements of the Audit as defined for the model. Final definition of actions to be taken is left to the individual charged with the task of implementation.

Action

The requirements of the Action stage are as follows:

- to implement actions providing the best return on investment first
- once resources are committed, to implement actions as quickly as possible
- to improve energy management awareness and technical skills of building managers and operators.

Working within the framework of the energy management model, there are several Action alternatives, one or more of which may be applied to any group of buildings. The following are offered by way of examples.

. Building Managers and Superintendents

The Ontario Ministry of Municipal Affairs and Housing has demonstrated the effectiveness of training building managers and superintendents in a competitive environment to implement

changes in their own buildings. Training programs were supplemented by energy audits and ongoing energy monitoring to provide direction and feedback. Success, with a very high average return on investment, was seen in 75 percent of the buildings, and was observed to be strongly dependent upon the interest and initiative of the participants. Action began within a few weeks of the start of the program, and took six months to complete.

Similar projects are underway with government buildings in Ontario and Saskatchewan.

- Local Consultants

  It is more expensive to use local consultants to implement actions, but the work may be completed more quickly. Terms of reference for the consultant should include instructing the building manager and superintendent in use of new and existing energy systems and controls.

- Contractors

  It generally costs little or nothing more than the cost of the work to have reliable contractors take responsibility for implementing specific actions identified as viable in the Audit. This category might include using summer students for specific programs such as insulating accessible hot water pipework. While contractors may not be able to tackle all necessary action in each building, they should provide quick and relatively inexpensive implementation. Their work should again be supplemented by training for the building managers and operators.

- Specially Assigned Personnel

  Provincial and C.M.H.C. personnel visit all projects from time to time for a variety of reasons. In many cases it may be possible to provide them with suitable instruction and include the energy management implementation mandate in their terms of

reference. This may result in energy retrofit being incorporated with other necessary contractor work in the projects, thereby reducing disruption and contract administration costs. Again, it would be necessary to provide supplementary training for building managers and operators. Where available, this alternative may provide an effective and inexpensive approach to implementation of energy management action.

Monitor

The requirements of the Monitoring stage are as follows:

- to motivate those implementing action by providing feedback on results of their work
- to isolate individual results of actions taken
- to show where predicted results are not being achieved
- to show where predicted results are being exceeded
- to identify projects which have reached their energy targets.

To provide these functions, the Monitor should be capable of analyzing ongoing energy bills to normalize for weather and billing period differences and of thereby providing monthly reports on savings and setbacks.

Database Reporting

The requirements of database reporting are as follows:

- to allow large numbers of energy audits to be grouped together to show total potential savings and budget costs so that appropriate levels of investment can be established, action programs planned, and resources allocated in the most effective manner
- to allow large numbers of energy monitors to be analyzed so that relative effectiveness of different action methods can be identified, the need for research in specific areas established, and return on investment for groups of buildings tracked

- to provide an accessible bank of energy and building information on participating projects
- to provide executive and exception reporting to all levels of management.

While Audit, Action and Monitor relate primarily to individual projects, Database Reporting serves to help the local housing authorities, the provinces and territories and C.M.H.C. to plan and manage the overall program and to obtain information to help with related policy decisions. For example, if it were considered desirable to support the glass manufacturing industry, the System might be interrogated to determine the total area of single glazed windows in oil heated buildings, and the cost and potential fuel savings from converting to double glazing.

Energy Information System

Energy Information System is the name adopted for a centralized system containing the Audit, Monitor and Database Reporting elements of the energy management model. Requirements of the Energy Information System are as follows:

- friendly, easy to use access to energy audits and monitoring for individual projects
- error checking procedures to ensure integrity of information
- powerful English based interrogation language for executive database reporting
- security of information to prevent access by unauthorized parties.

The success of such a system would depend upon its being useful and attractive at a local level, since individual building managers and housing authorities would be the major information providers. Figure 9.3 shows the system configuration for the energy audit, with energy bills and a building information questionnaire being used to generate reports on most projects and exception reports where anomalies or unusual situations are identified. Figure 9.4 shows the system for monitoring ongoing monthly energy use.

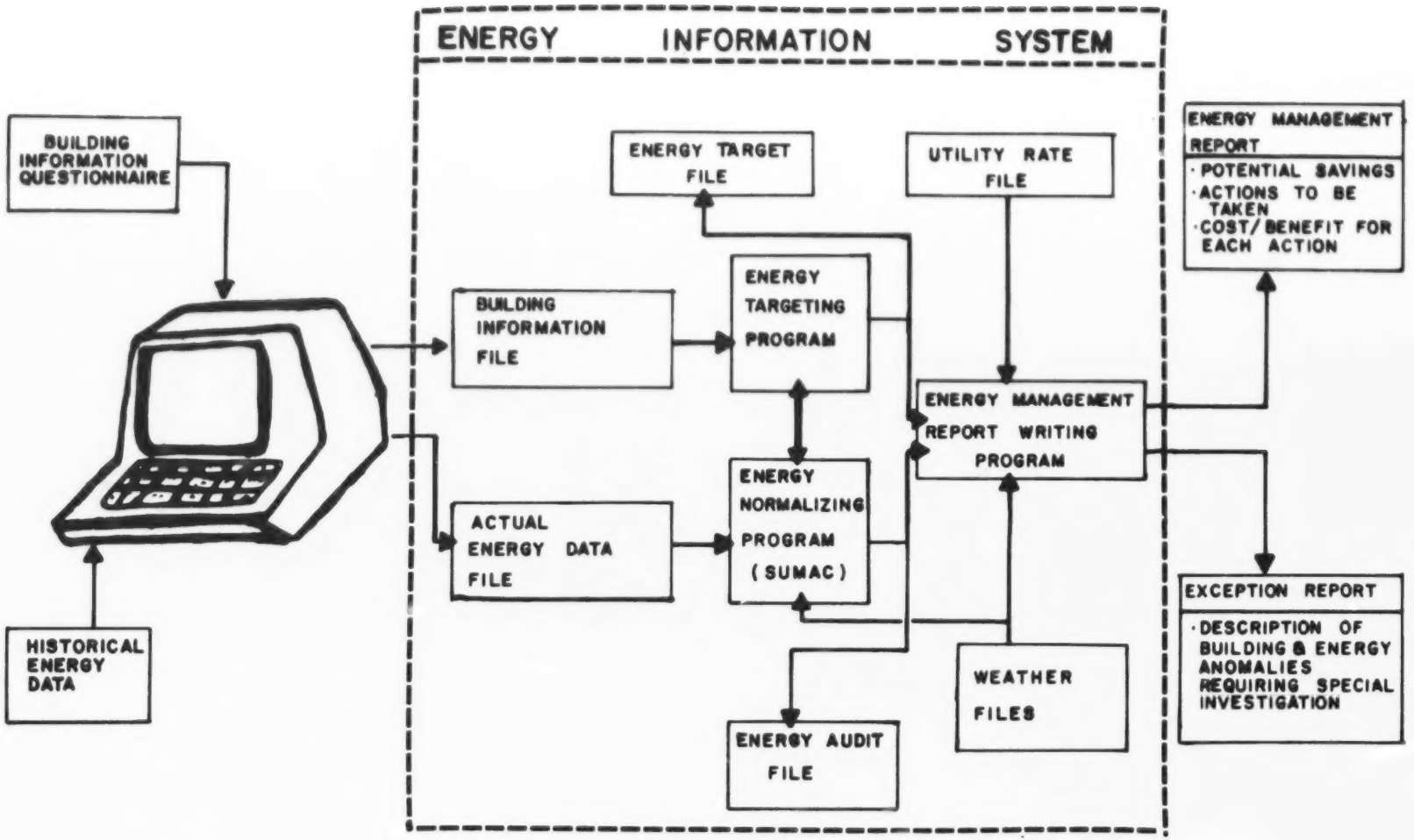


FIGURE-9.3 ENERGY INFORMATION SYSTEM
· THE ENERGY AUDIT

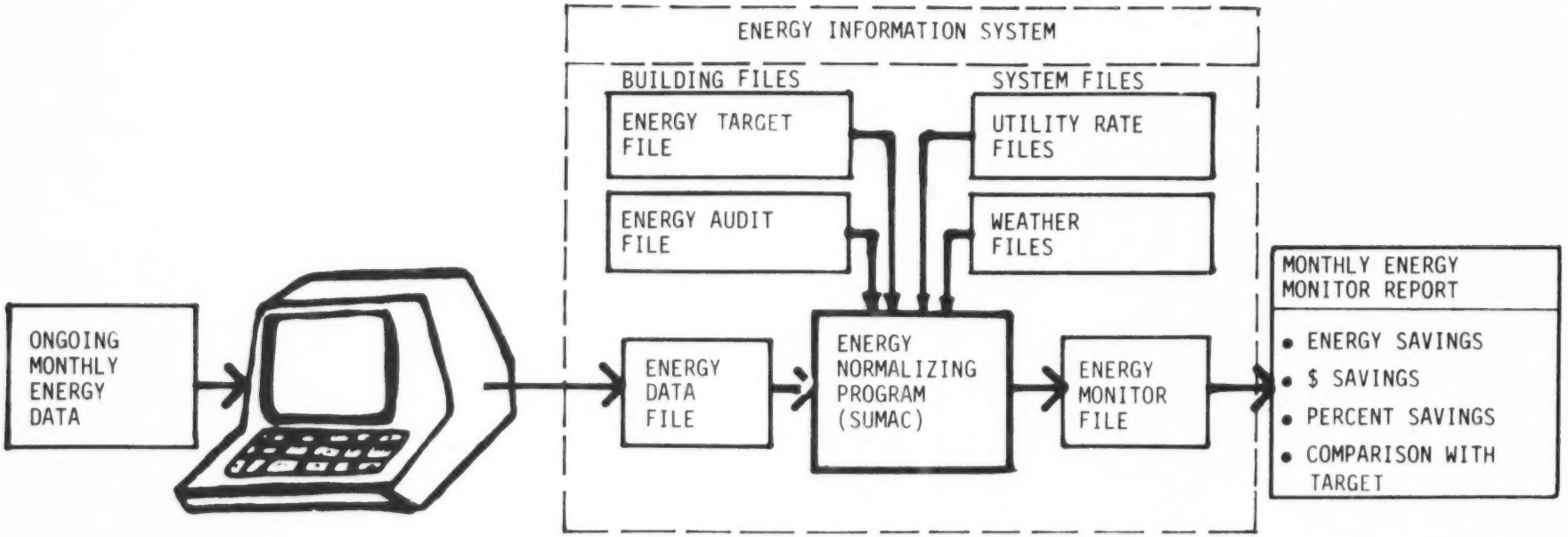


FIGURE 9.4 ENERGY INFORMATION SYSTEM
•THE ENERGY MONITOR

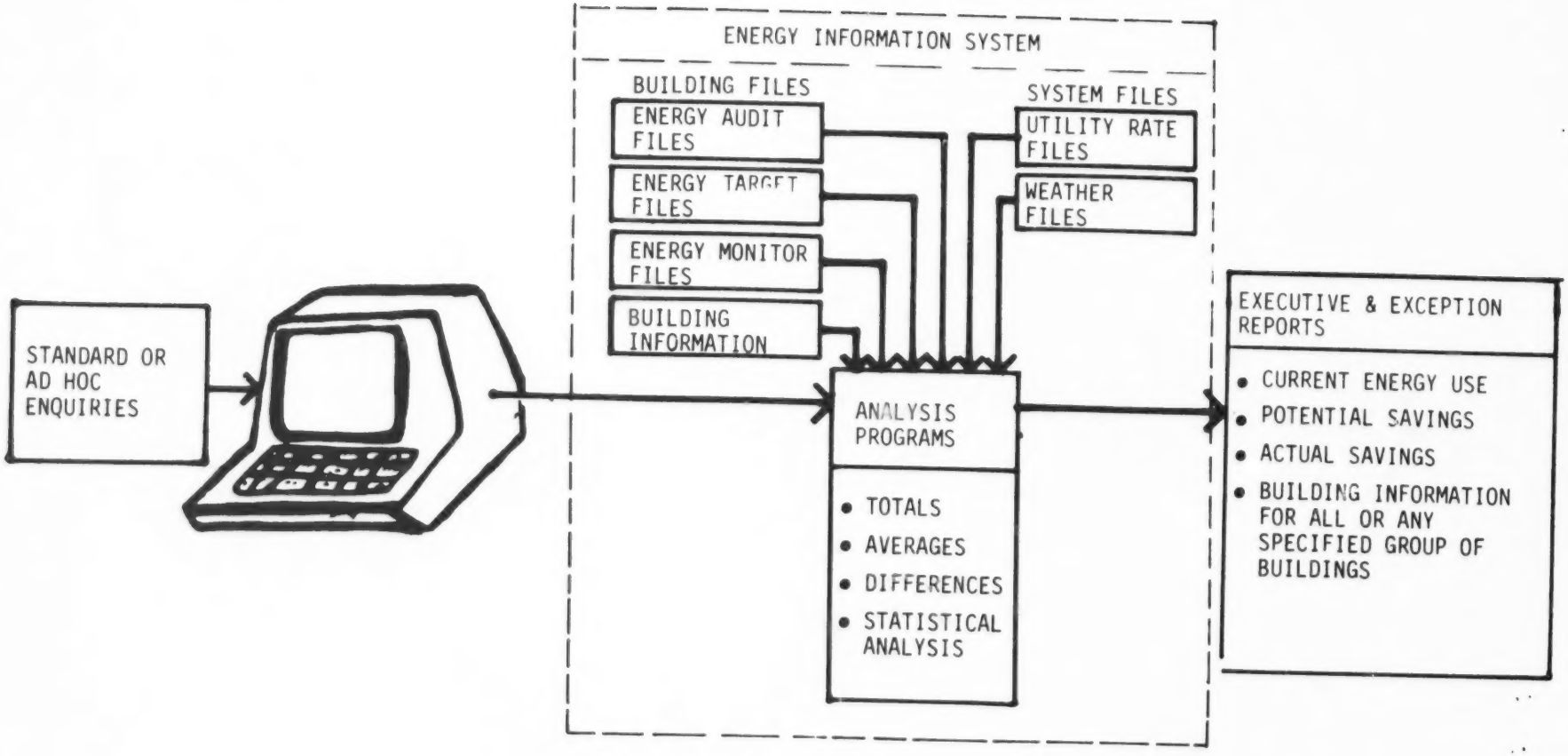


FIGURE-9.5 ENERGY INFORMATION SYSTEM
• EXECUTIVE AND EXCEPTION REPORTING

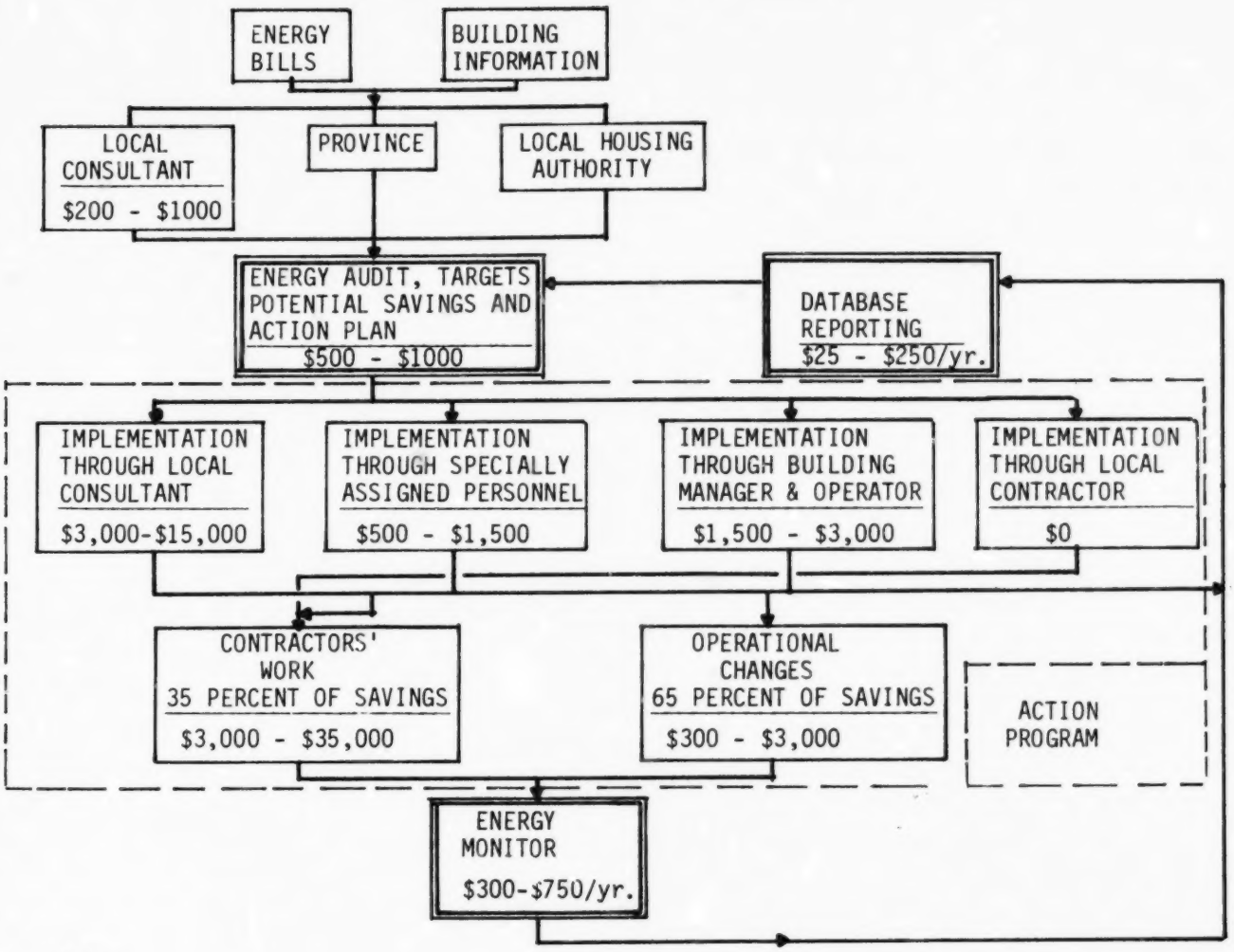
Once the information is contained in the system, then it becomes accessible to authorized users for executive and exception reporting as shown in Figure 9.5.

The technology of the Energy Information System is proven. Energy audit reports have been computer generated for 500 schools for the Province of British Columbia. A simplified energy targeting method has been developed by the Ontario Ministry of Municipal Affairs and Housing. Computerized energy auditing has been undertaken for at least two thousand Canadian buildings, while at least six hundred are being monitored by computer, and Canadian technology in these areas is ahead of the rest of the world. The System will introduce the local housing authorities to the use of computers for obtaining information and controlling all aspects of operating costs, which may prove to be the greatest long term benefit of the energy management program.

Financial Model

One of the major attractions of the Energy Information System is that it delivers consistent information and analysis to all users for relatively little cost.

While sample sizes used for this study are too small to allow firm estimates of costs and potential savings to be expected from energy management, Figure 9.6 is felt to provide realistic ranges of probable costs for the various elements and alternatives included in the energy management model. Retrieval of energy bills and building information for the energy audit will cost nothing if the housing authority or the province has them available, or may cost from $200 - $1,000 if a consultant is retained to obtain them. The energy audit stage should cost between $500 - $1,000, which is considered inexpensive by comparison with a normal range of $3,000 - $5,000 for the alternative of site surveys and consultant reports. Ranges of costs for defining and specifying actions and arranging implementation are shown for the four options discussed previously under Action.



Notes:

1. Costs shown are per building, and include outside services only.

2. Element of proposed Energy Information Systems, and key elements for consistency

3. Action Program according to needs and wants of Provinces and Local Housing Authorities.

FIGURE 9.6 **Energy Management Financial Model**

Expenditures on actions are separated into two parts; most savings generally come from relatively inexpensive operational changes, while more expensive contractors' work is normally required to obtain the remainder. Finally, anticipated cost ranges for monitoring and database reporting are also shown.

The financial model is intended to help plan implementation of the energy management model. For example, operational changes are almost invariably the most cost effective actions to be taken, while training of specially assigned personnel (Provincial or C.M.H.C.) is likely to be the least expensive implementation method.

By the time that this entire infrastructure is in place, implementation in all 1,650 projects is complete, and training programs for building managers and operators are fully operational, it is anticipated that up to $35 million will have been invested in this program. Five years is considered a realistic time frame for all of this.

Stage 2 - Testing the Model

It is recommended that the second stage of this study be directed towards testing the Energy Management Model. A second objective would be to increase the sample size of buildings subjected to energy analysis to allow the estimate of potential energy cost savings to be refined.

The proposed stage two would involve between 50 and 100 buildings from three or four regions in Canada. Energy audits would be produced as described previously in the Audit subsection. Local consultants would be retained to work with the housing authorities to implement selected actions, generally choosing those with the shortest payback. Ongoing energy use would be monitored to measure savings and track progress towards energy targets. The consultants would remain involved to ensure that operational changes remained in effect and that equipment performed well. One year after completion of implementation, results would be analyzed to assess

the validity and accuracy of the energy audits, to summarize actions taken, costs incurred and savings achieved, and to thereby refine the recommendations of this study as and if necessary to better reflect the situation in public housing in Canada.

The cost of this second stage should be between $158,000 and $220,000.

POOR

QUALITY

ORIGINAL